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NOTE:
This background discussion paper does not represent official policy and the views expressed herein are not necessarily the viewpoint of the Government of Ontario.

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World Mineral Markets
Stage III

A User Oriented Simulation Model of the World Markets for Copper, Aluminum, Nickel and Zinc

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EXECUTIVE SUMMARY

In *World Mineral Markets — Stage II* (1981), an econometric model of the world mineral markets was developed and applied to the markets for copper, aluminum, nickel and zinc. The primary features of this model are that it (1) explicitly incorporates the dynamic nature of these markets and (2) permits the existence of a disequilibrium. This model can be used to provide forecasts of future world consumption and price under alternative assumptions about future world economic and political conditions.

This monograph provides a *user-oriented* computer simulation model for the copper, aluminum, nickel, and zinc markets that makes it possible to quickly and easily obtain alternative simulations of the future values of consumption and price as world economic and political conditions change. No knowledge of computer programming is required to obtain the simulation; the number of required user commands has been kept to a minimum.

In order to consider changes in world economic or political conditions, the simulation model permits modifications in three general areas. First, changes can be made in the growth rates of the exogenous variables. For instance, one can obtain a simulation assuming that the rate of growth of capital accumulation in North America declines or the rate of growth in the money supply in Europe increases. Second, one can simulate the effect of politically-determined shocks to the market. Examples include such things as a reduction in production from Africa due to political instability or an increase in consumption by the centrally planned economies in response to a capital formation program. Third, the model can simulate the effects of the advent of new sources of production and/or consumption. Of particular interest is the entry of China into the world markets as well as the potential development of deep-seabed mining. Thus, the computer simulation model permits the user to obtain forecasts of particular interest by making modifications in one or a combination of these three general categories.

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INTRODUCTION

In *World Mineral Markets - Stage II: An Econometric and Simulation Approach to the World Markets for Copper, Aluminum, Nickel and Zinc* (1981), an econometric model of the world mineral markets was developed and applied to the markets for copper, aluminum, nickel, and zinc. The primary features of this model are that it (1) explicitly incorporates the dynamic nature of these markets and (2) permits the existence of a disequilibrium. Once the model has been estimated, it can be used to provide forecasts of future world consumption and price under alternative assumptions about future world economic and political conditions. Indeed, in the study itself, several such alternative simulations were provided. However, for the results of this study to attain their full potential, it is essential that users be able to obtain those simulations of particular interest in a timely fashion. For example, if a mineral producer finds that the growth rate of income in Europe has slowed significantly, it is essential to be able to obtain a prediction of the impact of this change in the economic environment on consumption and price. Likewise, if political instability disrupts the supply of a particular mineral commodity from, say, Africa, those involved in this market need a forecast of the effect.

Thus, the objective of this monograph is to provide a *user-oriented* computer simulation model for copper, aluminum, nickel, and zinc markets. This model will make it possible to quickly and easily obtain alternative simulations of the future values of consumption and price as world economic and political conditions change. The user-oriented nature of this model should be emphasized. No knowledge of computer programming is required to obtain the simulations; the number of required user commands has been kept to a minimum.

As has been noted, the simulation model was designed to indicate the effect of changes in the world economic and political environment on the mineral markets. In order to accomplish this, the simulation model permits modifications in three general areas. First, changes can be made in the growth rates of the exogenous variables. For instance, one can obtain a simulation assuming that the rate of growth of capital accumulation in North America declines or the rate of growth in the money supply in Europe increases. Second, one can simulate the effect of politically-determined shocks to the market. Examples include such things as a reduction in production from Africa due to political instability or an increase in production from South America due to a desire for more foreign exchange or an increase in consumption by the centrally planned economies in response to a capital formation program. Third, the model can simulate the effects of the advent of new sources of production and consumption. Of particular interest in this area is the entry of China into the world markets as well as the potential development of deep-seabed mining. Thus, the computer simulation model described in this monograph will permit the user to obtain forecasts of particular interest by making modifications in one or a combination of these three general categories.

The monograph is divided into two parts, followed by two appendices. Following is a brief description of the manner in which the material is arranged.

Part I reviews the econometric model and the simulation procedure. This review is drawn from *World Mineral Markets - Stage II*. Readers familiar with this earlier monograph may wish to skip this material. In Chapter 2, a general overview is provided. Chapter 3 presents the econometric model and the parameter estimates. In Chapter 4, the simulation methodology is described and the simulation model is evaluated. Specifically, forecasted values for the period 1977-1979 are compared with the actual values in order to examine the performance of the simulation model.

Part II contains the material of particular importance to this study. Chapter 5 provides an overview of the simulation procedures. Then, Chapter 6 presents the specific procedures for obtaining simulations. Included are instructions for a base simulation (i.e., all exogenous variables determined by historical trends), as well as for alternative simulations assuming changes in the growth rates of the exogenous variables, exogenous shocks to demand and/or supply, the advent of new sources of demand and/or supply, and combinations of the preceding. In each case, an example is provided. Chapter 7 concludes the discussion with some suggestions for potential extensions.

The appendices contain the more technical material. The program listing itself is presented in Appendix A. The program is written in Fortran; it should be compatable with most existing machines. Appendix B presents the instructions for updating and modifying the program.

PART I
The Model*

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*This discussion is adapted from C.W. Smithson, G. Anders, H. Hwang, and R.D. Martin, *World Mineral Markets - Stage II*, Ontario Ministry of Natural Resources, 1981.

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AN OVERVIEW

In this analysis, our primary objective was to develop an economic methodology for the examination of the world mineral markets. Although we explicitly examined some particular markets — copper, aluminum, nickel, and zinc — we wish to stress the fact that the techniques described would be applicable to other mineral markets.

Our analysis proceeds in two stages. First, we develop and estimate econometric equations that model the underlying structure of the mineral market. Second, we incorporate these estimated equations into a simulation model that may be used to generate predictions for the future values of primary production, secondary production, consumption, and price for the mineral, under alternative assumptions about world economic conditions.

Many, or perhaps most, of the preceding studies that have sought to project future values of a particular quantity have simply taken the past values of the quantity, determined the trend line that best fits these values, and projected that line into the future. While this technique has the advantage of simplicity, it does not allow for any analysis of the underlying market structure. Neither does a strict time series analysis allow one to examine the results of changes in any of the important variables that effect the market structure. In other words, such an analysis is too simplistic to give much insight into the functioning of the market or the impact of changes in important world economic parameters.

This study employs a basic supply-demand framework in order to analyze the world and its component mineral markets.[1] It does, of course, use historical data to estimate demand and supply equations that will be used in the simulation of future production, consumption, and prices; it does use time series data. However, once the equations are estimated, they are explicity incorporated in the simulation analysis. The basic structure of the market is then incorporated into our simulation model. In this way, our methodology differs from that of a strict time series analysis which would tend to veil the underlying structure.

As described in the preceding, this analysis is divided into two components — the econometric analysis and the simulation analysis. While these two components are not disjoint, it will probably be useful to consider them separately.

2.1 THE ECONOMETRIC ANALYSIS

In a traditional supply-demand framework, such as the one we employ, it is first necessary to define the suppliers and demanders. Since we consider the world market, the suppliers and demanders could be defined to be countries. However, since the number of countries involved make this approach impractical, we define the suppliers and demanders as country groups. Using a criterion of minimizing the number of groups while maintaining internal consistency, the world[2] was sub-divided into seven country groups: (1) North America, (2) Central and South America, (3) Asia, (4) Africa, (5) Europe, (6) Oceania, and (7) the Centrally Planned Economies.

For each of the country groups we specify and estimate a primary supply function, a secondary (scrap) supply function, and a consumption function. Then, since we consider a single world market, we must specify a market equilibrium and the relation of the actual market price to the, perhaps unrealized, equilibrium price. Following is a brief description of the manner in which these functions are specified.

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[1] In our analysis, we used as our point of departure the analysis of Fisher, Cootner, and Baily (1972). As should become clear, however, our analysis differs from theirs in that, in our analysis, we incorporate the dynamic nature of the mineral markets as well as the possibility of a market disequilibrium.

[2] We exclude China, Mongolia, the Democratic Republic of Korea, and the Democratic Republic of Viet Nam for which no data were available.

In general, the quantity supplied of a commodity could be specified to be a function of the real price of the commodity. However, the inherently dynamic nature of the production process in mineral extraction necessitates changes in this simple formulation. First, since the resource is depletable, current production depends on the amount of the resource that has been extracted in the past. Second, the dynamic nature of the process requires that the extracting firms maximize profit not simply in a given period but, rather, over the firms' relevant time horizons; the interest rate (discount factor) becomes a determinant of supply. Third, adjustments in the extractive industries take a considerable amount of time; so, it is likely that the producers form production plans on the basis of their expectations about future price and consumption levels. Finally, it is possible that, once market exchanges begin, the producers' expectations are not realized. In this case, we allow for the possibility that the producers are able to partially adjust to unanticipated price and demand conditions. Summarizing, we employ a supply function such that *planned* quantity supplied (primary production) is determined by expected price, expected consumption, the amount of the deposit previously extracted, and the interest rate. Then, we allow the suppliers to partially adjust their primary production (extraction) plans if their expectations are not realized.

In the case of secondary (scrap) production, it is necessary to consider both new scrap (i.e., that created in the fabricating process) and old scrap (i.e., that created through the destruction of existing fabricated products). New scrap production would depend on the real price of the mineral and on current consumption of the mineral (to reflect current fabricating activity). Old scrap production would depend on the price of the mineral and on the availability of fabricated products. Using past consumption of the mineral as a measure of the availability of fabricated products, we then define total secondary production to be a function of the price of the mineral and the consumption of the mineral in the current and past periods.

The demand for a mineral commodity is a derived demand. Minerals are not demanded for final consumption but rather as inputs in other production processes. Thus, we define quantity demanded to be a function of the real price of the mineral, the real price of commodities that are related to the mineral in the production process, and (as a proxy variable reflecting the demand for final products) real per capita income in the country group. It is, however, quite likely that the consumers of the mineral are also faced with the inability to adjust instantaneously to changes in market conditions. Hence, we again employ a specification in which the demanders determine their planned level of consumption on the basis of expectations and then may partially adjust this consumption plan if their expectations are not realized. That is, planned consumption is specified to be a function of the expected price of the mineral, the expected price of the related commodity, and expected real income. Then, if the expected values differ from the actual values, we provide a specification in which actual consumption can be partially adjusted from the planned consumption in response to the unanticipated market conditions.

In the context of the econometric specifications we use for supply and demand, the existence of an equilibrium would require that all expectations are realized. If this occurred, we could aggregate to obtain the world supply and demand functions and then solve these simultaneously to obtain an equilibrium (i.e., market clearing) price. As we demonstrated, such a solution requires that the price of the mineral be a function of the exogenous variables in the system as well as the lagged values of price, production, and consumption. However, in our analysis, we do not assume that the equilibrium is necessarily achieved. Instead, we assume only that the observed, actual price tends toward the unobservable equilibrium price. Incorporating this, we are then able to specify a reduced form equation for the price of the mineral.

From the preceding sketch, the reader should note that the primary difference between our model and other econometric approaches is that we explicitly incorporate the dynamic nature of the mineral markets. Neither the suppliers nor the demanders may be able to adjust instantaneously to changes in market conditions. Hence, in our analysis, we posit that production and consumption plans (or schedules) are made on the basis of expectations concerning the market conditions that will exist in the future. For the most part, we employ a "rational expectations" approach to the manner in which these expectations are formed.[3] Specifically, such an approach assumes that expectations about the future value of a variable are formed not only on the basis of the historical trend that has existed for that variable but also including additional variables, the values of which might be expected to alter the trend. Once exchanges begin to take place, the suppliers and/or demanders may find that their expectations are not realized and may wish to alter the production or consumption schedules. We allow for this possibility by employing a specification that allows partial adjustment of the production and consumption plans if the actual values differ from the expected values. Finally, it should be noted that this model employs disequilibrium analysis. We do not assume that a market-clearing equilibrium is necessarily attained. Instead, we assume only that the market tends toward equilibrium.

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[3] In some instances we will employ a simpler "adaptive expectations" approach.

2.2 THE SIMULATION ANALYSIS

In essence, our simulation procedure entails using the estimated econometric equations for primary production, secondary production, consumption, and price to generate projections of the future values of these variables. The techniques we use represent a combination of an iterative and an extrapolative approach. The iterative feature results from our use of the values predicted in one period as data to generate predictions for the next period. Extrapolation is used to predict the future values for the exogenous variables that are then used as data to simulate values for the variables under consideration.

Given the estimated primary supply, secondary supply, demand, and price equations using data from periods t, t-1, t-2 . . ., we wish to project these values for periods t+1, t+2, . . ., t+j. For data, we simply extrapolate the t+j values for the exogenous variables (i.e., the interest rates, real per capita income, and etc.) We then proceed to estimate the t+1 values. First we simulate price in period t+1. Then, using the simulated price in period t+1, we simulate consumption. Finally, employing the t+1 simulations of both price and consumption we simulate primary and secondary supply. The procedure is the same to simulate the t+2 values except that the simulated values for period t+1 are used as data in the simulation of the period t+2 values. For example the t+2 value for price is projected, using, as data, the simulated t+1 values for price, production, and consumption. This again is the iterative feature of our model. We simulate values for period t+i and then use these simulations as data in our simulation of the t+i+1 values.

We have attempted to design our simulation model to provide a considerable amount of flexibility. As we noted earlier, we use, as data points for the exogenous variables, the values extrapolated from historical trend. We can, obviously, obtain alternative simulations by making different assumptions about the future paths of these variables. In this way, one may use our basic model to obtain simulations for the future values of production, consumption, and price of a specific mineral under alternative assumptions about world economic conditions (e.g., if the growth rates in real per capita income are lower than those that have existed historically). Furthermore, the model itself can be modified to reflect changes in the structure of the mineral market. For instance, one could simulate the effect on production, consumption, and price of a specific mineral of altered production or consumption by a specific country group due to national policy changes (.e.g., if African production decreases by 10% due to political difficulties).

- 3 -

THE ECONOMETRIC MODEL

In this analysis we use a traditional supply-demand framework in order to incorporate the underlying structure of the world mineral markets. In such, a primary objective was to include the inherently dynamic nature of these markets. We define both the suppliers and demanders to be country groups. Then, it is necessary to specify a primary supply function, a secondary (scrap) supply function, and a demand function for each of these country groups. Since we assume that the mineral is traded on a single world market, we consider a single world price and, therefore, we need only to specify a single price formation equation.

In section 3.1 we describe our country groupings and the manner in which the data for the exogenous variables were collected. In sections 3.2 through 3.5 we review the formulation of the primary supply functions, the secondary supply functions, the demand functions, and the price equation that were used. Our estimation techniques are described in section 3.6. Then, the actual results of the estimations are presented in section 3.7.

3.1 THE COUNTRY GROUPINGS

In a traditional supply-demand framework, such as the one employed in our analysis, it is necessary to define the suppliers and the demanders. Since we use a world model, the most appropriate specification would be to define the suppliers and demanders as nations. However, given the sheer bulk of data using such an approach, this specification was modified to consider groups of countries.

In specifying the groupings, the criterion used was to limit the number of groups to a manageable size while maintaining consistency within the group. On the basis of this criterion, the world (excluding China, Mongolia, the Democratic Republic of Korea, and the Democratic Republic of Viet Nam for which no data are available) was divided into seven country groups:

(1) North America (Canada and USA)
(2) Caribbean, Central, and South America
(3) Asia (including Israel and Japan)
(4) Africa
(5) European Market Economies
(6) Oceania
(7) Centrally Planned Economies (Albania, Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, Rumania, USSR, and Yugoslavia).

Country group specific data were required for real income, the rate of capital accumulation, the interest rate, and the rate of growth of the money supply. Following is a brief description of these data.

For our income measure we employed the "index of per capita gross domestic product" from the *United Nations Statistical Yearbook*. These data were available for the period 1950-1976.

To reflect the rate of capital accumulation, we used the rate of change in the "index of gross fixed capital formation" also obtained from the *United Nations Statistical Yearbook*. Data were not available for the centrally planned economies. Furthermore, this series was considerably shorter than that for income in the case of South America, Asia, and Africa.

We were able to obtain interest rate data for only three of the country groups — North America, Europe and Oceania. In general, we obtained our measure of the interest rate in the country groups by calculating the weighted sums of the yields of long-term government bonds for the major countries in the group. These yields were obtained from *International Financial Statistics*. The countries considered were the United States and Canada for North America; Great Britain, France, and West Germany for Europe; and Australia and New Zealand for Oceania. The weights applied to specific countries were calculated as the five-year averages of the ratio of the gross domestic product of the country to the total gross domestic product of the group, where all data were converted to U.S. dollars.[1]

The rates of growth of the money supply in North America, Europe, and Oceania were calculated in the same manner as the interest rates. In this case, we obtained an index of money growth rates for individual countries from *International Financial Statistics* and then calculated the weighted average rate for the country group.[2]

3.2 PRIMARY PRODUCTION

In general, the quantity supplied of a particular commodity is specified to be a function of the price of the commodity in question, the price of the inputs used in the production of the commodity, and the level of available technology. We normally simplify this by using the real (deflated) price of the commodity to reflect both the price of the commodity itself and the price of the inputs. However, in the case of the extraction of mineral commodities, this simple formulation must be altered to reflect the dynamic nature of the production process. Following is a brief description of these features we feel are most important.

Since the resource is depletable, current production [extraction] would depend on the amount of the resource that has already been extracted. That is, an increase in the rate of extraction in any one period increases the cost of extracting a given amount in future periods; so, increased production in the past tends to reduce current output. In our estimations this feature is incorporated by including the total extracted in preceding periods ($\sum^{t-1} Q^S_{M,i}$) as an explanatory variable.

The fact that we are dealing with a dynamic process implies that the firm will not simply maximize current profits but will instead maximize profit over the relevant time horizon (i.e., maximize its present value or net worth). This requires that the interest rate, r, be a determinant of quantity supplied. If we do not consider inventory holding, an increase in the interest rate tends to increase the rate of current extraction. Conversely, since an increase in the interest rate increases the cost of holding inventories, the effect of an increase in the interest rate might be to decrease the rate of current extraction. Hence, we know that the interest rate will be a determinant of quantity supplied; but, the direction of the effect is not known.

Finally, adjustment to changes in demand conditions may involve a considerable amount of time. Coupled with the dynamic nature of the production process, this feature implies that output decisions are made on the firms' expectations concerning demand conditions. More specifically, we assume that the firms make production *plans* on the basis of their expectations about future price and consumption.

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[1] The interest rates for West Germany were not available prior to 1956. In order to approximate these rates, we used a regression interpolation. We found the most satisfactory fit to be that using the discount rate (DIS) as the explanatory variable. The following regression equation was estimated for 1956-1977 and used to obtain interest rates for 1947-1955.

$$r_t^{\text{GERMANY}} = 1.913 + 0.561\ \text{DIS}_t + 0.448\ \text{DIS}_{t-1} + 0.284\ \text{DIS}_{t-2}$$

$$R^2 = 0.84$$

While we could have simply used the weighted average for Great Britain and France for the period 1947-1955, we noted that the German interest rates are generally much higher than the other two in the early part of our sample. Consequently, if we used only the weighted average for Great Britain and France, the resulting series would show a large jump between 1955 and 1956 (when German data becomes available).

[2] In this case, data for the money supply in West Germany were unavailable prior to 1949. Rather than employ a regression interpolation, we simply used the weighted average for Great Britain and France only for the first two years.

Including the preceding features in our supply function, we define the *planned* primary production of mineral M by a specific country group in period t as

$$Q^{Sp}_{M,t} = f(P^{e}_{M,t}\,,\, D^{e}_{M,t}\,,\, t,\, r_t,\, \sum^{t-1} Q^{S}_{M,i}) \qquad (3\text{-}1)$$

In this,

$Q^{Sp}_{M,t}$ = the planned production by a specific country group of mineral M in period t

$P^{e}_{M,t}$ = the expected real price of mineral M in period t

$D^{e}_{M,t}$ = the expected world consumption of mineral M in period t

t = time = a proxy for the level of available technology

r_t = the interest rate prevailing in the country group at period t

$\sum^{t-1} Q^{S}_{M,i}$ = the amount of mineral M previously extracted in the country group

In order to obtain an estimating equation it is necessary to specify (1) the manner in which expectations are formed and (2) the relation between planned and actual production.

In our analysis, we employ a rational expectations form for the formation of price expectations. In such, expectations are formed not only on the basis of historical trend but also by including additional information that may alter the trend. In our analysis, we include the difference between world primary production and world consumption (to reflect changes in the world inventory level) as this additional information. In the case of expected consumption we employ a simpler, adaptive expectations formulation.

To specify the relation between planned and actual production, we employ a formulation that allows the producer some latitude in partially revising his expectations once exchanges have begun. We incorporate an adjustment parameter for both price and demand to allow the producers to partially adjust if expectations are not realized.

After incorporating these features, the final supply function in linear form is

$$\begin{aligned} Q^S_{M,t} = \theta_0 &+ \theta_1 P_{M,t} + \theta_2 P_{M,t-1} + \theta_3 \, ROWS_{M,t-1} \\ &+ \theta_4 D_{M,t} + \theta_5 D_{M,t-1} + \theta_6 t \\ &+ \theta_7 r_t + \theta_8 r_{t-1} \\ &+ \theta_9 \Sigma^{t-1} Q^S_{M,i} + \theta_{10} Q^S_{M,t-1} \end{aligned} \tag{3-2}$$

where,

$Q^S_{M,t}$ = the actual primary production by a specific country group of mineral M in period t

$P_{M,t}$ = the actual real price of mineral M in period t

$ROWS_{M,t}$ = the primary production from all country groups other than the one in question in period t

$D_{M,t}$ = actual world consumption of mineral M in period t

t = time

r_t = the interest rate prevailing in the country group in period t

We make the following hypotheses concerning the signs of the parameters:

θ_0 indeterminant

θ_1 ≥ 0

θ_2 indeterminant

θ_3 indeterminant

θ_4 ≥ 0

θ_5 indeterminant

θ_6 indeterminant

θ_7 indeterminant

θ_8 indeterminant

$\theta_9 < 0$

θ_{10} indeterminant

It should, however, be noted that the parameters θ_1 and θ_4 reflect respectively the adjustment to unanticipated price and demand conditions. It is possible that adjustment is impossible (or prohibitively expensive). If the producers are unable to adjust production in response to unanticipated price conditions, $\theta_1 = 0$ and it follows that $\theta_2 > 0$ and $\theta_3 < 0$. If the producers are unable to adjust to unanticipated price or consumption conditions ($\theta_1 = 0$ and $\theta_4 = 0$) it follows that $\theta_5 > 0$.

3.3 SECONDARY PRODUCTION

Secondary (scrap) production may be subdivided into two categories. New scrap is created in the fabricating process itself, while old scrap is that created by destruction of existing fabricated products.

New scrap production may be specified to be a function of the real price of the mineral commodity and, to reflect current fabricating activity, the current level of consumption. The amount of old scrap forthcoming depends on the real price of the mineral commodity and the total amount of the mineral commodity available for recovery. In this, the amount available for recovery is, of course, a function of previous consumption levels of the mineral commodity. It follows then that total scrap production of mineral M by a specific country group in period t may be specified as

$$Q^{SCRAP}_{M,t} = f\,(P_{M,t}, Q^{D}_{M,t}, Q^{D}_{M,t-1}, Q^{D}_{M,t-2}, \ldots) \tag{3-3}$$

where

$Q^{SCRAP}_{M,t}$ = secondary production by a specific country group of mineral M in period t

$P_{M,t}$ = the real price of mineral M in period t

$Q^{D}_{M,t}$ = the consumption in the country group of mineral M in period t.

Using the mathematical rules concerning infinite series and a linear specification, we can transform equation (3-3) into the following estimation equation.

$$\begin{aligned} Q^{SCRAP}_{M,t} = {} & \phi_0 + \phi_1^P P_{M,t} + \phi_2^P P_{M,t-1} + \phi_3^P P_{M,t-2} \\ & + \phi_1^D Q^{D}_{M,t} + \phi_2^D Q^{D}_{M,t-1} + \phi_3^D Q^{D}_{M,t-2} + \phi_4^D Q^{D}_{M,t-3} \\ & + \phi_5 Q^{SCRAP}_{M,t-1} \end{aligned} \tag{3-4}$$

In this formulation, the following hypotheses are made about the signs of the parameters:

ϕ_0 indeterminant

$\phi_1^P > 0$

$\phi_2^P < 0$

$\phi_3^P > 0$

$\phi_1^D < 0$

ϕ_2^D indeterminant

ϕ_3^D indeterminant

ϕ_4^D indeterminant

$\phi_5 > 0.$

3.4 DEMAND

The demand for a mineral commodity is a *derived* demand. Mineral commodities are demanded not for final consumption but rather as inputs in other production processes. In this way, the demand for minerals is derived from the demand for those final products that use the mineral input.

In this context we might then specify the quantity demanded of mineral M by a specific country group in period t as a function of the real price of the mineral commodity, the real price of commodities that are related to the mineral in the final production process, and (as a proxy variable reflecting the demand for final output) real per capita income in the country group. However, we feel that some of the dynamic features discussed in the context of primary production would also be present in the consumption decision. Specifically, we would argue that the demanders are also unable to adjust instantaneously to changes in market conditions; we will employ a specification in which the demanders determine their planned level of consumption on the basis of their expectations and then may partially adjust this plan if their expectations are not realized.

It follows then that we will specify planned consumption as

$$Q_{M,t}^{D^P} = f\,(P_{M,t}^e, P_{R,t}^e, Y_t^e) \tag{3-5}$$

where,

$Q_{M,t}^{D^P}$ = planned consumption of mineral M

$P_{M,t}^e$ = the expected real price of mineral M in period t

$P_{R,t}^e$ = the expected real price of the related commodity in period t

Y_t^e = expected real per capita income in the country group in period t

As was the case with primary production, in order to obtain an estimation equation from (3-5) it is necessary to specify (1) the manner in which expectations are formed and (2) the relation between planned and actual consumption.

For the expected real price of the mineral we employ exactly the same rational expectations approach used in primary production. We posit that price expectations are formed on the basis of both historical trend and changes in the world inventory level (measured by the difference between world primary production and world consumption). We employ the simpler adaptive expectations approach for the formation of the expected price of the related commodity. Finally, for expected real per capita income we use a rational expectations framework in which expectations are formed not only on the basis of the historical trend in income but also by incorporating information on the trends in capital accumulation and the growth of the money supply.

As with primary production, we will employ a specification that allows the demanders to partially revise their consumption plans if their expectations are not realized. We incorporate adjustment parameters for the price of the mineral, the price of the related commodity, and income reflecting the degree to which the demanders may adjust their production plans in response to unanticipated market conditions.

Incorporating these specifications (and imposing homogeneity of degree zero in $P_{M,t}$ and $P_{R,t}$), the estimating equation is

$$\begin{aligned} Q_{M,t}^D = {} & \Psi_0 + \Psi_1 (P_{M,t} - P_{R,t}) + \Psi_2 (P_{M,t-1} - P_{R,t-1}) + \Psi_3 (S_{M,t-1} - D_{M,t-1}) \\ & + \Psi_4 Y_t + \Psi_5 Y_{t-1} + \Psi_6 K_{t-1} + \Psi_7 M_{t-1} \qquad (3\text{-}6) \\ & + \Psi_8 Q_{M,t-1}^D \end{aligned}$$

where

$Q_{M,t}^D$ = actual consumption by a specific country group of mineral M in period t

$P_{M,t}$ = actual real price of mineral M in period t

$P_{R,t}$ = actual real price of the related commodity in period t

$S_{M,t}$ = world primary production of mineral M in period t

$D_{M,t}$ = world consumption of mineral M in period t

Y_t = actual real per capita income in the country group in period t

$\dot{K}_t$ = the rate of real capital accumulation in the country group in period t

$\dot{M}_t$ = the rate of growth of the money supply in the country group in period t

We hypothesize the following concerning the signs of the parameters in equation (3-6):

Ψ_0 indeterminant

$\Psi_1 < 0$

Ψ_2 indeterminant

Ψ_3 indeterminant

$\Psi_4 > 0$

Ψ_5 indeterminant

Ψ_6 indeterminant

Ψ_7 indeterminant

$\Psi_8 > 0$

It should be noted that Ψ_1 and Ψ_4 represent the partial adjustment parameters. If the demanders are unable to adjust to unanticipated price conditions, $\Psi_2 < 0$ and $\Psi_3 > 0$. Likewise, if the demanders are unable to adjust to unanticipated income conditions, $\Psi_4 = 0$ and $\Psi_5, \Psi_6,$ and Ψ_7 would be positive.

3.5 MARKET PRICE

In the econometric model we have developed, the existence of an equilibrium would require that the suppliers' and demanders' expectations are realized. In such an instance we could obtain the equilibrium price by (1) summing primary and secondary production for each country group to obtain a total supply function, (2) summing the total supply and demand functions over the country groups to obtain world supply and demand functions over the country groups to obtain world supply and demand, and (3) solving the world supply and demand functions for the equilibrium (i.e., market clearing) price. In such a solution, the equilibrium price would be a function of the lagged values of price, consumption, and production (both primary and secondary) as well as current values of the exogenous variables — time, the interest rate, the price of related commodity, and income.

In our specification we do not assume that the equilibrium is necessarily achieved. Instead we assume only that the actual (observed) price tends toward this unobservable equilibrium price. Incorporating this, our estimation equation is

$$\begin{aligned} P_{M,t} = \eta_0 &+ \eta_1 P_{M,t-1} + \eta_2 P_{M,t-2} + \eta_3 (S_{M,t-1} - D_{M,t-1}) + \eta_4 t \\ &+ \eta_5 r_t + \eta_6 \sum^{t-2} S_{M,i} + \eta_7 WQ^{SCRAP}_{M,t-1} \qquad (3\text{-}7) \\ &+ \eta_8 P_{R,t} + \eta_9 P_{R,t-1} + \eta_{10} P_{R,t-2} + \eta_{11} Y_t \end{aligned}$$

where

$P_{M,t}$ = the real price of mineral M in period t

$S_{M,t}$ = world primary production of mineral M in period t

$D_{M,t}$ = world consumption of mineral M in period t

r_t = the interest rate in period t

$WQ^{SCRAP}_{M,t}$ = world secondary production of mineral M in period t

$P_{R,t}$ = the real price of the related commodity in period t

Y_t = income in period t.

In essence equation (3-7) represents the reduced form equation for price. In this instance we make no hypotheses concerning the signs of the parameters. Finally it should be noted that, in this specification, r_t and Y_t should represent the world interest rate and world per capita income. Given the aggregation problems involved we use in our estimations the North America values for these variables.

3.6 ESTIMATION TECHNIQUES

The reader will note that the estimating equations incorporate endogenous variables as explanatory variables. These include not only lagged values (e.g., $Q^S_{M,t-1}$) but also current values (e.g., $P_{M,t}$). Clearly, the inclusion of these variables results from the simultaneity of the system. The problem exists, however, that, in this case, traditional ordinary least squares estimation would result in biased estimates of the co-efficients; so, we must employ a simultaneous equations estimation technique. In this study we employ the two-stage least squares technique treating the lagged endogenous variables as predetermined (i.e., exogenous) variables.

We do, however, encounter a difficulty imposed by the small sample sizes for some of the country groups. Using the two-stage least squares estimation technique to obtain estimates for a market, all of the exogenous (and predetermined) variables relevant for that market should be used as instrumental variables. In some instances the period over which we have data for a country group is simply too short to use all of the variables as instruments (e.g., South America, Asia, and Africa in the case of the demand for aluminum). In such cases, we were required to reduce the number of instrumental variables, concentrating on those variables which, theoretically, are the more significant determinants of the included endogenous variables.

We should also note that we treated the prices of related commodities as exogenous variables. Although it might be more appropriate to treat them as endogenous variables, such a procedure would require the incorporation of the simultaneity of the individual mineral markets (e.g., the copper and aluminum markets would be estimated simultaneously). Such a procedure was simply beyond the scope of this project.

As the reader may be aware, the proposed two-stage least squares estimation technique would be appropriate only if there exists no serial correlation in the error term. In their study of the copper market, Fisher, Cootner, and Baily hypothesized that autocorrelation may well be present. Since the simple Durbin-Watson statistic is biased in the presence of lagged endogenous variables, we employed the method suggested by Hatanaka[3] to test for this autocorrelation. We estimated our equations for several important country groups using this technique. In all cases, serial correlation was not found to be statistically significant. It follows then that the two-stage least squares estimation technique will be acceptable for this project.

Finally, we must stress the fact that the sign predictions made in the preceding sections were made on the basis of the implicit assumption that the explanatory variables are independent. It is quite possible that some of these hypothesized relations may hold due simply to multicolinearity in our data.

3.7 ESTIMATES

In this section we present the results of our estimations. For each of the four minerals, we first describe the data employed then present the parameter estimates. For a discussion of these estimates, the reader should see *An Econometric and Simulation Approach to the World Mineral Markets.*

3.7.a COPPER

In order to perform our estimations, data were required for primary production, secondary production, and consumption of copper by country group, as well as the world price of copper and the related commodity. In this analysis, we use aluminum as the related commodity, since aluminum is the principal substitute for copper. All data were collected from *Metal Statistics.* Following is a brief description of the data.

For primary production we use mine production, expressed in thousand metric tons. In the case of secondary production, we employed the reported data for scrap recovery, expressed in thousand metric tons. Data were available only for North America, South America, Asia, Europe, and Oceania.

Consumption data were available only for refined copper. These data are expressed in thousand metric tons.

For the world price of copper, we used the London Metal Exchange (LME) price for electrolytic copper wirebars. While we acknowledge the difficulties introduced by the two-market system that has existed,[4] we feel that this price more accurately reflects a market determined price. The LME price is expressed in pounds Sterling per long ton. We converted this into U.S. cents per pound. Then, since our models are specified in terms of the real price of the mineral, we deflated this nominal price by the U.S. wholesale price index (1967=100).

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[3] M. Hatanaka, "An Efficient Two-Step Estimator for the Dynamic Adjustment Model with Autoregressive Errors," *Journal of Econometrics*, 1974, 199-220.

[4] See Banks (1974) and Fisher, Cootner, and Baily (1972).

The world price of aluminum was defined to be the U.S. price for 99.5% aluminum ingots in cents per pound. Although this variable has been criticized,[5] we feel that it is more appropriate than the alternative measures. It was also deflated by the U.S. wholesale price index (1967=100). Our estimates are displayed in Tables 3-1 through 3-4.

3.7.b ALUMINUM

As primary production, we employed the data reported for production of primary aluminum expressed in thousand metric tons. For secondary production we used the data for scrap recovery expressed in thousand metric tons. In the case of aluminum, data were available for all of the country groups except the centrally planned economies. The consumption of aluminum by country group is also expressed in thousand metric tons.

The world price of aluminum was defined to be the U.S. price for 99.5% aluminum ingots in cents per pound. We realize that the U.S. price may have some characteristics of an administered price, but, we feel that the variable is more appropriate than the London or German prices. To express these values in real terms, we deflated the nominal values by the U.S. wholesale price index (1967=100).

Finally, the world price of copper was defined to be the London Metal Exchange (LME) price for electrolyte copper wirebars. After reviewing the discussions of the two-market system for copper, we felt that this is the most appropriate variable to reflect a market for copper. Since this variable is reported as pounds Sterling per long ton, we converted it to U.S. cents per pound and deflated it with the U.S. wholesale price index (1967=100).

The parameter estimates for aluminum are displayed in Tables 3-5 through 3-8.

3.7.c NICKEL

In addition to the country group data described earlier, data were required for primary production, secondary production, and consumption, as well as the world price of nickel and of the related commodity. In this analysis, we will use, as the related commodity, raw steel.[6] The data for the price of raw steel were obtained from the *American Metal Market* statistics and the remainder of the data were collected from *Metal Statistics*. Following is a brief description of these data.

For primary production, we employed the data reported on mine production, expressed in thousand metric tons. In the case of nickel, secondary (scrap) production (i.e., scrap recovery) was reported only for the United States. In our analysis, we treat this as world secondary production. Data for the consumption of refined nickel in thousand metric tons were also collected.

As the world price of nickel, we used the U.S. price for electrolytic cathodes denominated in cents per pound. In order to convert these nominal prices into real prices, we deflated these values by the U.S. wholesale price index (1967=100). The world price of raw steel was defined to be the U.S. steel billet price in dollars per net ton. These values were also deflated by the U.S. wholesale price index (1967=100).

3.7.d ZINC

As with the other minerals, data were required for primary production, secondary production, and consumption of zinc by country group as well as the world price of zinc and of the related commodity. We will use, as the related commodity, raw steel.[7] The majority of the data were collected from *Metal Statistics*. Following is a brief description of the data.

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[5] See Fisher, Cootner, and Baily (1972).

[6] While it is clear that certain types of steel and nickel are used together in production, it is not clear that such a relation always holds. Thus we will not hypothesize *a priori* about the substitutability or complementarity of steel and nickel.

[7] Although we make no explicit hypothesis, we expect zinc and raw steel to be complements rather than substitutes in the production of final commodities.

We use, for primary production, the reported data for mine production, expressed in thousand metric tons. For secondary production we employ the data on scrap recovery, expressed in thousand metric tons. In the case of zinc, the data were such that only total world secondary production is usable.[8] Consumption of zinc is again expressed in thousand metric tons.

We define the world price of zinc to be the U.S. price in cents per pound.[9] To convert this nominal price into a real price, it was deflated by the U.S. wholesale price index (1967=100). The world price of steel is defined as the U.S. steel billet price in dollars per net ton. This value was obtained from *American Metal Market Statistics*. These values were also deflated by the U.S. wholesale price index (1967=100).

The parameter estimates are displayed in Tables 3-13 through 3-16.

[8] Data were reported for the United States, Japan and western countries, total. We felt that, given these data, a total world secondary production function would be most appropriate.

[9] More specifically, we used the EMJ price for prime western zinc in East St. Louis.

TABLE 3-1
ESTIMATED EQUATIONS
PRIMARY PRODUCTION
COPPER
(T-STATISTICS IN PARENTHESES)

		North America 1952-1976	South America 1952-1976	Asia 1952-1976	Africa 1952-1976	Europe 1952-1976	Oceania 1952-1976	Centrally Planned 1952-1976
θ_0	Constant	300.8920 (0.1782)	-1587.09 (-1.5241)	85.4435 (0.3782)	-1063.49 (-1.5440)	-700.2360 (-1.6793)	472.2330 (1.1998)	-344.858 (-1.1844)
θ_1	$P_{M,t}$		1.6620 (0.5563)	0.4449 (0.5015)		0.9507 (1.1922)	1.6589 (1.1224)	
θ_2	$P_{M,t-1}$	6.2525 (1.5930)	-0.8037 (-0.5152)	0.7336 (1.8391)		-0.1077 (-0.2646)	-1.8313 (-1.4660)	1.6715 (1.9922)
θ_3	$ROWS_{M,t-1}$	0.6708 (1.9057)	0.0852 (0.5210)	0.0419 (0.9866)	-0.0138 (-0.2406)	0.0660 (2.0815)	0.1182 (1.4830)	0.0425 (0.8403)
θ_4	$D_{M,t}$	0.5061 (4.5440)		0.0231 (1.4478)	0.0521 (1.5712)	0.0094 (0.7452)		0.0007 (0.0218)
θ_5	$D_{M,t-1}$	-0.2436 (-1.5118)	-0.0887 (-0.6781)	-0.0433 (-1.4718)	0.0079 (0.2248)	-0.0452 (-2.1050)	-0.0026 (-0.0360)	-0.0288 (-0.7224)
θ_6	t	-30.1440 (-0.8850)	39.0058 (1.9299)	-2.9154 (0.6766)	27.2426 (1.8609)	12.0909 (1.5370)	-14.8840 (-1.5772)	5.4933 (0.8398)
θ_7	r_t	26.5248 (0.4086)	NA	NA	NA	-5.6891 (-0.5683)	-26.5812 (-1.0092)	NA
θ_8	r_{t-1}	101.9810 (1.3034)	NA	NA	NA	13.8761 (1.6991)	34.0857 (0.9765)	NA
θ_9	$\Sigma^{t-2} Q^S_{M,i}$	-0.0810 (-2.1560)	-0.0137 (0.4345)	-0.0030 (-0.1506)	-0.0056 (-0.3925)	-0.1863 (-2.0840)	-0.0283 (-0.4520)	-0.0105 (-0.6256)
θ_{10}	$Q^S_{M,t-1}$	0.2280 (1.0068)	0.2261 (0.5443)	0.9707 (4.5329)	0.1581 (0.6615)	0.7826 (1.7746)	0.7702 (2.6270)	1.0578 (4.0941)
	R^2	0.9676	0.9569	0.9922	0.9857	0.9566	0.9620	0.9976
	SEE	96.7742	56.3958	11.6735	40.0443	9.6135	31.2156	24.4527

TABLE 3-2
ESTIMATED EQUATIONS
SECONDARY PRODUCTION
COPPER
(T-STATISTICS IN PARENTHESES)

		North America 1952-1976	South America 1967-1976	Asia 1952-1976	Europe 1952-1976	Oceania 1962-1976
ϕ_0	Constant	-42.9657	-15.7970	0.1277	-70.9817	-19.0611
		(-1.1154)	(-1.4475)	(0.0137)	(-1.3774)	(-1.5382)
ϕ_1^P	$P_{M,t}$	2.5640	0.2370	0.5298	3.0077	0.2158
		(3.1316)	(1.6815)	(1.8702)	(3.1027)	(0.8958)
ϕ_2^P	$P_{M,t-1}$	-1.6662	-0.0086	-0.1909	-0.3807	-0.0550
		(-1.6742)	(-0.0619)	(-0.6764)	(0.3178)	(-0.1633)
ϕ_3^P	$P_{M,t-2}$					0.3801
						(1.5400)
ϕ_1^D	$Q^D_{M,t}$	0.0689	0.0442	0.0631	0.0474	0.2281
		(1.8272)	(0.8982)	(3.2277)	(0.6593)	(0.6359)
ϕ_2^D	$Q^D_{M,t-1}$	0.0112	-0.0220	0.0337	-0.0593	0.1949
		(0.2595)	(-0.4217)	(0.9493)	(-0.7494)	(0.5166)
ϕ_3^D	$Q^D_{M,t-2}$	-0.0163	0.0498	-0.0483	0.0790	-0.2247
		(-0.5201)	(2.3572)	(-2.0235)	(1.1795)	(-0.9896)
ϕ_4^D	$Q^D_{M,t-3}$					0.0138
						(0.0854)
ϕ_5	$Q^{SCRAP}_{M,t-1}$	0.6666	0.6242	0.3493	0.5421	
		(3.9492)	(0.9779)	(1.5652)	(2.9635)	
	R^2	0.9476	0.9852	0.9298	0.9148	0.7639
	SEE	26.4136	2.3446	9.8551	40.0227	5.6127

TABLE 3-3
ESTIMATED EQUATIONS
DEMAND
COPPER
(T-STATISTICS IN PARENTHESES)

		North America 1952-1976	South America 1962-1976	Asia 1962-1976	Africa 1962-1976	Europe 1952-1976	Oceania 1952-1976	Centrally Planned 1952-1976
Ψ_0	Constant	-114.826 (-0.4842)	-518.065 (-2.7784)	-291.800 (-0.5656)	-114.792 (-3.9083)	-106.671 (0.7070)	-67.2024 (-2.6201)	6.4491 (0.4069)
Ψ_1	$P_{M,t}-P_{R,t}$		-0.5497 (-0.3868)			-2.7735 (-0.7823)	-0.1706 (-0.6209)	
Ψ_2	$P_{M,t-1}-P_{R,t-1}$	-3.1211* (-0.9082)	-2.1104 (-1.5697)	-0.9659 (-0.1882)	-0.5824 (-3.1071)	-8.1560 (-2.5275)	-0.3774 (-1.8155)	-1.0715 (-1.7999)
Ψ_3	$S_{M,t-1}-D_{M,t-1}$	-0.3728 (-2.1467)	-0.0694 (-0.8837)	-0.0452 (-0.1914)	-0.0122 (-1.5672)	-0.1867 (-1.1391)	-0.0246 (-1.9769)	-0.0490 (-2.0045)
Ψ_4	Y_t	5223.39 (4.1918)	649.865 (0.9597)	4003.75 (2.2777)	13.8973 (0.2035)	3194.36 (2.0486)	290.696 (2.8854)	
Ψ_5	Y_{t-1}	-3424.65 (-2.2090)	112.119 (0.1457)	-3300.86 (-1.7130)	146.270 (1.7110)	-1089.49 (-0.6042)	-157.902 (-1.3612)	509.117 (2.7489)
Ψ_6	$\dot{K}_{t-1}$	831.093 (0.9988)	-80.1161 (-0.3312)	1154.48 (1.1363)	-131.461 (-2.8752)	2029.80 (2.6625)	96.4749 (1.9636)	NA
Ψ_7	$\dot{M}_{t-1}$	5.9988 (0.2890)	NA	NA	NA	-9.2975 (-0.8232)	-0.0260 (0.0770)	NA
Ψ_8	$Q^D_{M,t-1}$	-0.0059 (-0.0187)	-0.1371 (-0.3743)	0.1589 (0.3011)	0.6064 (4.3208)	0.1692 (0.8387)	0.2711 (1.0945)	0.6749 (4.9975)
	R^2	0.9169	0.9482	0.9124	0.9649	0.9694	0.9694	0.9947
	SEE	131.219	29.1006	112.048	5.0854	98.1609	6.4320	24.2376

* Estimated coefficient for $P_{M,t-2}-P_{R,t-2}$

TABLE 3-4
ESTIMATED EQUATIONS
PRICE
COPPER
(T-STATISTICS IN PARENTHESES)
1952-1976

η_0	Constant	54.2536 (0.2216)
η_1	$P_{M,t-1}$	-0.1445 (-0.4358)
η_2	$P_{M,t-2}$	-0.4109 (-1.8680)
η_3	$S_{M,t-1}-D_{M,t-1}$	-0.0273 (-1.8020)
η_4	t	-4.4307 (-0.8778)
η_5	r_t	-3.5678 (-0.8211)
η_6	$\sum^{t-2} S_{M,i}$	0.0002 (0.1805)
η_7	$WQ^{SCRAP}_{M,t-1}$	0.0142 (0.4990)
η_8	$P_{R,t}$	2.5548 (1.8904)
η_9	$P_{R,t-1}$	0.0172 (0.0097)
η_{10}	$P_{R,t-2}$	
η_{11}	Y_t	234.666 (3.0319)
	R^2	0.8396
	SEE	6.6513

TABLE 3-5
ESTIMATED EQUATIONS
PRIMARY PRODUCTION
ALUMINUM
(T-STATISTICS IN PARENTHESES)

		North America 1952-1976	South America 1952-1976	Asia 1952-1976	Africa 1959-1976	Europe 1952-1976	Oceania 1952-1976	Centrally Planned 1952-1976
θ_0	Constant	-2897.06 (-1.0042)	137.258 (1.0496)	537.813 (1.0576)	198.285 (0.4348)	840.791 (1.4506)	-5.5657 (-0.0085)	-2840.19 (-3.2146)
θ_1	$P_{M,t}$	30.6477 (1.2525)	4.9239 (2.1210)	1.8037 (0.1842)	1.9218 (0.4805)	1.6431 (0.1462)	4.3082 (0.5224)	15.1127 (0.9219)
θ_2	$P_{M,t-1}$	-2.8914 (-0.1291)	-6.1849 (-2.3179)	-0.3574 (-0.0380)	-0.9512 (-0.1432)	-7.8384 (-0.5991)	1.3817 (0.1451)	-1.6014 (-0.0838)
θ_3	$ROWS_{M,t-1}$	-0.4123 (-1.3622)	0.0552 (3.2533)	0.1274 (2.4524)	-0.0738 (-1.9831)	0.0355 (0.4005)	0.0064 (0.1148)	0.1212 (0.7933)
θ_4	$D_{M,t}$	0.3784 (9.2631)	0.0055 (1.0814)	0.0324 (2.1918)	0.0129 (1.5221)	0.0579 (1.7803)	0.0187 (1.3709)	0.0868 (2.4060)
θ_5	$D_{M,t-1}$	0.3548 (2.6701)	-0.0356 (-3.3244)	-0.0738 (-1.9831)	-0.0198 (-0.6908)	0.0396 (0.5581)	-0.0049 (-0.1371)	-0.0022 (-0.0233)
θ_6	t	47.9072 (0.7889)	-3.3201 (-1.0494)	-14.4830 (-1.3298)	-4.9218 (-0.5659)	-13.0657 (-1.0273)	-4.0795 (-0.4025)	46.8268 (2.2712)
θ_7	r_t	-10.8994 (-0.1439)	NA	NA	NA		-5.7795 (-0.2336)	NA
θ_8	r_{t-1}	161.381 (1.9133)	NA	NA	NA		10.6340 (0.3077)	NA
θ_9	$\overset{t-2}{\Sigma} Q^S_{M,i}$	-0.0429 (-1.0168)	-0.0412 (-1.3445)	-0.0837 (-3.3931)	0.0211 (0.2907)	0.0280 (0.6075)	-0.0101 (-0.0841)	0.0013 (0.0434)
θ_{10}	$Q^S_{M,t-1}$	-0.1359 (-0.6435)	0.6086 (2.3569)	1.2366 (5.0120)	0.4960 (1.5652)	0.3341 (0.7161)	0.7864 (1.8691)	-0.1936 (-0.6598)
	R^2	0.9965	0.9931	0.9972	0.9794	0.9979	0.9839	0.9946
	SEE	94.9076	10.3483	33.3499	19.6851	50.5061	23.7600	76.7957

TABLE 3-6
ESTIMATED EQUATIONS SECONDARY PRODUCTION ALUMINUM
(T-STATISTICS IN PARENTHESES)

		North America 1952-1976	South America 1952-1976	Asia 1952-1976	Africa 1952-1976	Europe 1952-1976	Oceania 1952-1976
ϕ_0	Constant	-54.7408 (-0.3160)	2.9039 (0.3404)	-10.7487 (-0.5964)	-0.9371 (-0.5026)	-29.7566 (-0.6897)	-1.7844 (-0.4809)
ϕ_1^P	$P_{M,t}$	2.8214 (0.2653)	0.2940 (0.4548)		0.0207 (0.2020)		
ϕ_2^P	$P_{M,t-1}$	-1.0774 (-0.1215)	-0.5360 (-0.9812)		0.0335 (0.3668)	1.8970 (1.1189)	
ϕ_3^P	$P_{M,t-2}$			0.4498 (0.6007)			0.0245 (0.1523)
ϕ_1^D	$Q^D_{M,t}$	0.1050 (3.6202)	0.1267 (3.1716)	0.216[illegible] (14.1865)	0.0142 (0.5576)	0.2579 (11.8466)	0.1220 (3.7002)
ϕ_2^D	$Q^D_{M,t-1}$	-0.0716 (-2.1456)	0.0176 (0.3202)	0.0047 (0.0965)	0.0014 (0.0556)	-0.1538 (-2.4600)	-0.0357 (-0.8335)
ϕ_3^D	$Q^D_{M,t-2}$	0.0569 (1.7861)	-0.0632 (-1.5786)	-0.1365 (-4.1599)	-0.0050 (-0.2114)	0.0164 (0.7328)	-0.0795 (-2.6943)
ϕ_4^D	$Q^D_{M,t-3}$			0.0213 (1.1178)			0.1173 (2.4312)
ϕ_5	$Q^{SCRAP}_{M,t-1}$	0.6935 (3.8695)	0.3777 (1.8161)	0.6317 (3.2424)	0.8835 (5.9443)	0.6279 (2.9754)	0.3942 (1.8799)
	R^2	0.9801	0.9841	0.9990	0.9744	0.9966	0.9851
	SEE	59.1218	2.7135	7.0244	0.6042	18.5207	1.5857

TABLE 3-7
ESTIMATED EQUATIONS
DEMAND
ALUMINUM
(T-STATISTICS IN PARENTHESES)

		North America 1952-1976	South America 1962-1976	Asia 1962-1976	Africa 1962-1976	Europe 1952-1976	Oceania 1952-1976	Centrally Planned 1952-1976
Ψ_0	Constant	-7442.93 (-4.7027)	-576.526 (-2.4323)	-1311.98 (-1.5984)	-277.958 (-2.4312)	-775.586 (-1.4194)	-314.555 (-6.1073)	-176.866 (-1.7498)
Ψ_1	$P_{M,t}-P_{R,t}$	-14.6924 (-2.2299)	-0.5681 (-1.1073)		-0.1813 (-0.9958)	-6.3905 (-1.8569)		-1.2201 (-1.1343)
Ψ_2	$P_{M,t-1}-P_{R,t-1}$	17.4787 (2.7127)	1.3230 (2.1113)		0.0787 (0.4532)	3.9309 (0.9198)	-0.0890 (-0.3646)	-1.7754 (-1.4940)
Ψ_3	$S_{M,t-1}-D_{M,t-1}$	-0.5254 (-1.3475)	-0.0318 (-1.5144)		0.0048 (0.7481)	0.0516 (0.5393)	0.0006 (0.0888)	0.0421 (1.1909)
Ψ_4	Y_t	9832.74 (2.8188)	12.5735 (0.0264)	6395.91 (3.7401)	145.537 (1.5643)	6105.14 (2.7929)	221.562 (1.9654)	1193.00 (1.4652)
Ψ_5	Y_{t-1}	3504.77 (0.9192)	823.674 (1.1014)	-4528.01 (-2.7539)	205.501 (1.4565)	-4466.15 (-1.5497)	263.590 (1.6138)	-260.201 (-0.2801)
Ψ_6	$\dot{K}_{t-1}$	1486.39 (0.9017)	7.7562 (0.0472)	1471.78 (1.3197)	-33.0556 (-0.3868)	-862.369 (-0.9706)	11.3677 (0.1963)	NA
Ψ_7	$\dot{M}_{t-1}$	-73.7263 (-1.5090)	NA	NA	NA	10.5161 (0.7739)	0.9156 (2.2923)	NA
Ψ_8	$Q^D_{M,t-1}$	-0.3829 (-1.3341)	0.1024 (0.2767)	0.1720 (0.3935)	0.1267 (0.3658)	0.5822 (1.9999)	-0.3256 (-1.5894)	0.5942 (2.9924)
	R^2	0.9794	0.9888	0.9769	0.9852	0.9863	0.9835	0.9967
	SEE	238.704	17.9878	111.624	6.2653	127.562	9.4081	49.4283

TABLE 3-8
ESTIMATED EQUATIONS
PRICE
ALUMINUM
(T-STATISTICS IN PARENTHESES)
1952-1976

η_0	Constant	-3.8888 (-0.3178)
η_1	$P_{M,t-1}$	0.3738 (1.0976)
η_2	$P_{M,t-2}$	-0.2233 (-0.8600)
η_3	$S_{M,t-1}-D_{M,t-1}$	0.0018 (1.1698)
η_4	t	0.5961 (1.9655)
η_5	r_t	1.6056 (2.4030)
η_6	$\sum^{t-2} S_{M,i}$	-0.00003 (-0.4263)
η_7	$WQ^{SCRAP}_{M,t-1}$	-0.0049 (-1.5518)
η_8	$P_{R,t}$	0.0223 (0.6896)
η_9	$P_{R,t-1}$	0.0855 (2.2187)
η_{10}	$P_{R,t-2}$	
η_{11}	Y_t	-19.7233 (-1.5973)
	R^2	0.8747
	SEE	0.9999

TABLE 3-9
ESTIMATED EQUATIONS
PRIMARY PRODUCTION
NICKEL
(T-STATISTICS IN PARENTHESES)

		North America 1952-1976	South America 1952-1976	Asia 1953-1976	Africa 1952-1976	Europe 1952-1976	Oceania 1952-1976	Centrally Planned 1952-1976
θ_0	Constant	-536.046 (-0.7542)	3.5136 (0.0174)	-21.6663 (-1.1821)	85.8054 (4.5632)	12.9107 (1.2577)	198.652 (0.8957)	-128.379 (-1.3868)
θ_1	$P_{M,t}$	2.1440 (0.7740)		0.1378 (1.2432)	0.3340 (2.8874)	0.1138 (2.2994)	2.8391 (1.9561)	0.8205 (1.2063)
θ_2	$P_{M,t-1}$	-0.8400 (-0.5349)	0.4237 (0.7243)	-0.0828 (-0.7419)	0.3163 (2.3567)	0.0210 (0.3351)	-0.4690 (-0.5444)	-1.1070 (-2.0839)
θ_3	$ROWS_{M,t-1}$	-0.5490 (-0.9192)	0.0043 (0.0587)	-0.0020 (-0.1345)	-0.0188 (-1.4301)	-0.0000 (-0.0161)	0.2237 (1.7667)	0.1287 (1.6040)
θ_4	$D_{M,t}$	0.2143 (0.8894)	0.0928 (1.1546)	-0.0165 (-1.1553)	0.0495 (3.4183)	0.0268 (2.9159)	0.3414 (1.3624)	0.1005 (1.0257)
θ_5	$D_{M,t-1}$	0.3496 (1.9889)	-0.0319 (-0.3328)	0.0022 (0.1652)	0.0364 (1.4617)	-0.0037 (-0.3533)	0.1452 (1.5028)	-0.0137 (-0.1853)
θ_6	t	11.2255 (0.7246)	-0.7306 (-0.1601)	0.3727 (0.8550)	-2.6074 (-5.4514)	-0.5123 (-2.0467)	-10.6321 (-1.8494)	2.3793 (1.1963)
θ_7	r_t	-27.4274 (-1.7050)	NA	NA	NA	-0.1084 (-0.2332)	12.5823 (1.3231)	NA
θ_8	r_{t-1}	21.5487 (0.9856)	NA	NA	NA	0.3058 (0.4551)	9.7655 (0.4758)	NA
θ_9	$\Sigma^{t-2} Q^S_{M,i}$	-0.0310 (-0.2683)	-0.1195 (-0.8336)	0.1173 (1.6653)	0.2736 (6.1019)	0.0252 (0.6481)	-0.0492 (-1.0557)	-0.0499 (-1.8801)
θ_{10}	$Q^S_{M,t-1}$	-0.3191 (-1.3744)	0.9513 (6.3520)	0.6637 (1.6290)	-0.4809 (-1.7839)	0.6059 (2.1608)	-0.1467 (-0.4527)	0.7002 (3.6632)
	R^2	0.8942	0.8516	0.9789	0.9909	0.9944	0.9822	0.9669
	SEE	23.5007	10.4052	1.6087	1.6479	0.7794	11.6190	9.8449

TABLE 3-10
ESTIMATED EQUATIONS
NICKEL
(T-STATISTICS IN PARENTHESES)
1952-1976

ϕ_0	Constant	-4.7355 (-0.6651)
ϕ_1^P	$P_{M,t}$	
ϕ_2^P	$P_{M,t-1}$	0.1414 (1.0547)
ϕ_3^P	$P_{M,t-2}$	
ϕ_1^D	$Q^D_{M,t}$	0.0188 (0.1732)
ϕ_2^D	$Q^D_{M,t-1}$	-0.0053 (-0.1982)
ϕ_3^D	$Q^D_{M,t-2}$	-0.0175 (-0.6156)
ϕ_4^D	$Q^D_{M,t-3}$	
ϕ_S	$Q^{SCRAP}_{M,t-1}$	0.5675 (2.1271)
	R^2	0.6847
	SEE	4.5439

TABLE 3-11
ESTIMATED EQUATIONS
DEMAND
NICKEL
(T-STATISTICS IN PARENTHESES)

		North America 1952-1976	South America 1962-1976	Asia 1962-1976	Africa 1962-1976	Europe 1952-1976	Oceania 1952-1976	Centrally Planned 1952-1976
Ψ_0	Constant	-60.9557 (-1.6284)	-13.6289 (-2.0457)	-55.2326 (-1.0974)	-5.6538 (-1.7770)	-109.555 (-3.8180)	-4.5199 (-2.9994)	-1.1321 (-0.2449)
Ψ_1	$P_{M,t}-P_{R,t}$					-0.5936 (-1.0195)		-0.3983 (-1.2859)
Ψ_2	$P_{M,t-1}-P_{R,t-1}$	-0.3715 (-0.6197)				0.3463 (0.6189)		-0.0537 (-0.1911)
Ψ_3	$S_{M,t-1}-D_{M,t-1}$	-0.1417 (-1.4997)			-0.0068 (-1.8544)	-0.1564 (-2.4651)		-0.0058 (-0.1861)
Ψ_4	Y_t	326.385 (2.4820)	32.6026 (0.8391)	486.279 (2.9587)	2.3808 (0.2912)	656.184 (3.4234)	15.2643 (2.1459)	9.5325 (0.0963)
Ψ_5	Y_{t-1}	-104.639 (-0.6652)	-15.9706 (-0.3785)	-408.513 (-2.1637)	5.6490 (0.6970)	-363.461 (-1.5960)	-7.7967 (-1.0138)	23.0372 (0.2211)
Ψ_6	$\dot{K}_{t-1}$	118.352 (1.7264)		91.7363 (0.7488)	-5.5333 (-0.9343)	30.6500 (0.4069)	2.0027 (0.4796)	NA
Ψ_7	$\dot{M}_{t-1}$	0.6513 (0.3157)	NA	NA	NA	-0.8690 (-0.8332)	0.0272 (1.0172)	NA
Ψ_8	$Q^{D}_{M,t-1}$	-0.0001 (-0.0006)	0.2464 (0.8530)	0.3353 (0.7887)	0.7115 (4.0414)	-0.1446 (-0.5141)	0.0133 (0.0601)	0.8189 (7.0297)
	R^2	0.9013	0.7414	0.9247	0.9298	0.9726	0.8306	0.9820
	SEE	12.4285	2.2510	12.3505	0.5893	10.3081	0.6699	5.9106

TABLE 3-12
ESTIMATED EQUATIONS
PRICE
NICKEL
(T-STATISTICS IN PARENTHESES)
1952-1976

η_0	Constant	-14.4384 (-0.3742)
η_1	$P_{M,t-1}$	0.7411 (3.1621)
η_2	$P_{M,t-2}$	-0.0570 (-0.2443)
η_3	$S_{M,t-1}-D_{M,t-1}$	0.0040 (0.1079)
η_4	t	1.2517 (1.1965)
η_5	r_t	5.2895 (1.8431)
η_6	$\sum^{t-2} S_{M,i}$	-0.0018 (-0.6237)
η_7	$WQ^{SCRAP}_{M,t-1}$	-0.0616 (-0.1787)
η_8	$P_{R,t}$	
η_9	$P_{R,t-1}$	0.3479 (1.1001)
η_{10}	$P_{R,t-2}$	-0.8846 (-3.0241)
η_{11}	Y_t	-10.0084 (-0.2263)
	R^2	0.9719
	SEE	4.0389

TABLE 3-13
ESTIMATED EQUATIONS
ZINC
(T-STATISTICS IN PARENTHESES)

		North America 1952-1976	South America 1952-1976	Asia 1952-1976	Africa 1952-1976	Europe 1952-1976	Oceania 1952-1976	Centrally Planned 1952-1976
θ_0	Constant	-2290.86 (-2.1425)	2384.92 (2.8506)	-698.097 (-3.6228)	-4564.43 (-2.8250)	-2231.52 (-0.5798)	-1331.89 (-1.0722)	-250.630 (-0.6096)
θ_1	$P_{M,t}$			5.1231 (2.1903)	6.0170* (1.8573)	9.1588 (0.8900)		
θ_2	$P_{M,t-1}$	35.9861 (2.9115)	0.5355 (0.1543)	0.7384 (0.4971)	-2.5143* (-0.8225)	-3.0990 (-0.7036)	5.2670 (0.7472)	6.6680 (1.2138)
θ_3	$ROWS_{M,t-1}$	0.1033 (0.4149)	0.0059 (0.1620)	0.0583 (2.8580)	0.0053 (0.1523)	0.0721 (1.4836)	0.0461 (0.9276)	0.0358 (0.5490)
θ_4	$D_{M,t}$	0.3176 (3.1907)	0.0868 (3.5731)	0.0036 (0.3175)	0.0192† (0.9625)	0.0596 (0.6305)	0.0622 (0.7560)	0.0463 (1.5490)
θ_5	$D_{M,t-1}$	0.0921 (1.4204)	-0.0197 (-0.7651)	-0.0242 (-1.8574)	-0.0445† (-1.0409)	-0.1097 (-1.9524)	0.0413 (0.9586)	0.0378 (1.5814)
θ_6	t	25.9613 (1.5750)	-45.0289 (-2.9369)	10.5899 (3.4600)	93.8334 (2.9165)	41.5993 (0.6049)	21.2747 (1.2186)	1.5683 (0.2497)
θ_7	r_t	1.0545 (0.0231)	NA	NA	NA	18.8497 (1.1159)	-27.3258 (-1.7113)	NA
θ_8	r_{t-1}	6.3047 (0.1062)	NA	NA	NA	5.0576 (0.1347)	49.0637 (1.1783)	NA
θ_9	$\sum^{t-2} Q^{S}_{M,i}$	-0.0749 (-1.9607)	0.0876 (2.7647)	-0.0489 (-2.9099)	-0.3547 (-2.8914)	-0.0893 (-0.5738)	-0.1078 (-1.0065)	-0.0032 (-0.1476)
θ_{10}	$Q^{S}_{M,t-1}$	0.4614 (3.1343)	0.3139 (1.7090)	0.7071 (2.4231)	0.0284 (0.1147)	0.7367 (3.0912)	0.1803 (0.6437)	0.6321 (2.0630)
	R^2	0.9822	0.9787	0.9957	0.6638	0.9726	0.9568	0.9964
	SEE	65.7841	26.5206	9.4423	16.6421	22.6878	24.8486	24.7898

* Respectively $P_{M,t-1}$ and $P_{M,t-2}$

† Respectively $D_{M,t-1}$ and $D_{M,t-2}$

TABLE 3-14
ESTIMATED EQUATIONS
SECONDARY PRODUCTION
ZINC
(T-STATISTICS IN PARENTHESES)
1952-1976

ϕ_0	Constant	168.399 (2.0675)
ϕ_1^P	$P_{M,t}$	3.2410 (0.6926)
ϕ_2^P	$P_{M,t-1}$	0.6341 (0.1076)
ϕ_3^P	$P_{M,t-2}$	
ϕ_1^D	$Q^D_{M,t}$	0.1557 (6.3620)
ϕ_2^D	$Q^D_{M,t-1}$	-0.0942 (-1.6556)
ϕ_3^D	$Q^D_{M,t-2}$	-0.0229 (-0.5054)
ϕ_4^D	$Q^D_{M,t-3}$	
ϕ_5	$Q^{SCRAP}_{M,t-1}$	0.5037 (2.3366)
	R^2	0.9421
	SEE	31.7785

TABLE 3-15
ESTIMATED EQUATIONS
DEMAND
ZINC
(T-STATISTICS IN PARENTHESES)

		North America 1952-1976	South America 1962-1976	Asia 1962-1976	Africa 1962-1976	Europe 1952-1976	Oceania 1952-1976	Centrally Planned 1952-1976
Ψ_0	Constant	203.834 (1.3602)	-72.9145 (-0.5113)	34.9991 (0.1269)	-194.291 (-3.3679)	-59.5058 (-0.5171)	-22.2901 (-1.2543)	-14.7821 (-1.0692)
Ψ_1	$P_{M,t}-P_{R,t}$	-2.8353 (-0.3701)						
Ψ_2	$P_{M,t-1}-P_{R,t-1}$	2.2260 (0.3404)	-2.4797 (-2.3199)	-1.8330 (-0.3780)	-1.2465* (-1.6342)	-5.0264 (-2.0939)	-0.6187 (-1.7011)	
Ψ_3	$S_{M,t-1}-D_{M,t-1}$	-0.0713 (-0.6499)	0.0171 (0.7677)	0.1028 (1.4690)	0.0222 (2.5788)	-0.2102 (-1.9634)	-0.0265 (-2.6537)	
Ψ_4	Y_t	4327.82 (3.6193)	384.042 (1.4755)	2547.14 (2.3088)	187.079 (1.6707)	4432.36 (4.4376)	230.119 (2.1440)	764.045 (2.4203)
Ψ_5	Y_{t-1}	-4333.05 (-3.6643)	-513.396 (-2.1095)	-2849.61 (-3.0499)	-11.4363 (-0.1023)	-3033.38 (-2.3102)	-123.653 (-1.0964)	-235.507 (-0.6620)
Ψ_6	$\dot{K}_{t-1}$	-102.535 (-0.1675)	-10.1757 (-0.1467)	869.824 (2.0286)	-86.4222 (-1.2222)	948.244 (1.7582)	1.4490 (0.0244)	NA
Ψ_7	$\dot{M}_{t-1}$	1.7915 (0.0829)	NA	NA	NA	-5.9214 (-1.0109)	0.3551 (0.9076)	NA
Ψ_8	$Q^D_{M,t-1}$	0.7264 (2.3855)	1.0113 (1.3574)	0.8940 (3.1203)	-0.0218 (-0.0595)	-0.2407 (-0.6204)	-0.1675 (-0.6058)	0.5233 (2.7687)
	R^2	0.8946	0.9821	0.9709	0.9410	0.9735	0.9001	0.9969
	SEE	85.4713	9.7926	51.5827	7.3524	57.7512	9.3241	20.2731

*Estimated coefficient for $P_{M,t-2}-P_{R,t-2}$

TABLE 3-16
ESTIMATED EQUATIONS
PRICE
ZINC
(T-STATISTICS IN PARENTHESES)
1952-1976

η_0	Constant	108.525 (4.3935)
η_1	$P_{M,t-1}$	0.5241 (3.6851)
η_2	$P_{M,t-2}$	-0.3482 (-1.6303)
η_3	$S_{M,t-1}-D_{M,t-1}$	-0.0022 (-1.1850)
η_4	t	-1.6662 (-4.1352)
η_5	r_t	-1.1448 (-1.4761)
η_6	$\Sigma^{t-2} S_{M,i}$	0.0006 (4.1189)
η_7	$WQ^{SCRAP}_{M,t-1}$	-0.0557 (-0.6690)
η_8	$P_{R,t}$	
η_9	$P_{R,t-1}$	-0.2792 (-2.9008)
η_{10}	$P_{R,t-2}$	0.2112 (2.6249)
η_{11}	Y_t	-7.3347 (-0.6330)
	R^2	0.9183
	SEE	1.1397

- 4 -

THE SIMULATION METHODOLOGY

The final objective of this project was to provide simulations of the future values of world price and of production and consumption (both for the world and for individual country groups) for various minerals. In essence, this entails using the econometric models described in Chapter 3 to provide projections of the future values of these variables. In this chapter we will describe the methodology employed to generate these projections.

We begin with a verbal description of the techniques that will be used. We then turn to a more technical discussion of the manner in which these techniques were implemented. We conclude this chapter with an evaluation of the simulation model, comparing the predicted and actual values for the period 1977-1979.

4.1 BASIC TECHNIQUES

The simulation techniques used in this analysis represent a combination of an iterative and an extrapolative approach. The iterative feature results from the fact that the values of the relevant variables in one period are used in our econometric models to generate simulated values for the next period; then, these simulated values are themselves used as data to generate simulations for the next period and so on. The model is extrapolative in the sense that it uses trend to obtain future values of the exogenous variables that may then be used as data in our econometric models to simulate values for the variables under consideration.

Our technique may be summarized briefly as follows. Given the primary supply, secondary supply, and demand functions for each country group and our price formation equation estimated using data for periods t, t-1, t-2, . . ., t-i, we wish to project primary and secondary supply and demand for each country group as well as world production, consumption, and price for periods t+1, t+2, . . ., t+J.

Let us first consider our simulations for period t+1. We begin with the simulation of price, since this equation does not include any current endogenous variables and the price term will be required in the succeeding simulations. To simulate price in period t+1, we use as data the actual values of price, world primary production, world consumption, and world scrap production in period t as well as extrapolated values for the exogenous variables — the interest rate, the price of the related commodity, and income — in period t+1. We then use this simulated price as data in our demand functions to simulate quantity demanded in period t+1. That is, quantity demanded in period t+1 by a specific country group is determined by our simulated price of the mineral commodity in period t+1 in addition to actual values for the price of the mineral, the price of the related commodity, world primary production, world consumption, income, the rates of capital acquisition and growth of the money supply, and quantity demanded in period t and the extrapolated values for the price of the related commodity and income in period t+1. Summing over the country groups we obtain a simulated value for world consumption of the mineral commodity in period t+1. Next, we employ the simulated values of the price of the mineral commodity and quantity demanded in period t+1 to simulate secondary production in period t+1. The scrap production from a specific country group is determined by these variables as well as the actual values in period t of price, consumption, and scrap production. Again, the world scrap production is obtained simply by summing over the country groups. Finally we incorporate our simulated values for price and world consumption in our estimated primary supply functions to simulate primary production in period t+1. The quantity supplied in period t+1 by a specific country group is determined by the simulated values of the price of the mineral and world consumption in period t+1 as well as the actual values in period t of price, primary supply from the rest of the country groups, consumption, the interest rate and primary quantity supplied and the extrapolated value of the interest rate in period t+1. Then simulated total world primary production is simply the sum of these values for the seven country groups.

In order to simulate values for period t+2, we need to repeat the procedures used to simulate the t+1 values. However, the latter used observable data from period t and, in the case of the simulations for period t+2, we require (unobserved) data from period t+1. Hence, in our simulations for period t+2 we use the simulated values for period t+1 as data. As mentioned earlier, this is the iterative feature of our model. We simulate values for period t+i and then use these t+i simulations as data in the simulation of the t+i+1 values.

The simulation model is designed to provide a considerable amount of flexibility. As we have noted, we use as data points for the exogenous variables — the price of related commodities, the interest rate, income, and the rates of capital accumulation and money stock growth — values extrapolated from historical trend. Clearly, we can alter our simulations by making alternative assumptions concerning the future paths of these variables. Indeed, we can make many alternative simulations to reflect potential changes in the world economic environment and/or changes in the structure of the model itself. For example, an alternative simulation can be obtained assuming that the rate of growth in income (output) in a specific country group is slower or faster than that indicated by historical trend. Or, we can simulate a situation to indicate the results of increased production by a specific country group because of national policy changes rather than market forces.

4.2 IMPLEMENTATION OF THE SIMULATION MODEL

We begin with the primary supply, secondary supply, demand, and price equations estimated using data from the period 1952-1976. To review from Chapter 3, the form of these equations is as follows:

(1) World Price

$$\begin{aligned} P_{M,t} = {} & \eta_0 + \eta_1 P_{M,t-1} + \eta_2 P_{M,t-2} + \eta_3 (S_{M,t-1} - D_{M,t-1}) + \eta_4 t \\ & + \eta_5 r_t + \eta_6 \sum^{t-2} S_{M,i} + \eta_7 WQ^{SCRAP}_{M,t-1} \\ & + \eta_8 P_{R,t} + \eta_9 P_{R,t-1} + \eta_{10} P_{R,t-2} + \eta_{11} Y_t \end{aligned} \tag{4-1}$$

(2) Demand in a Specific Country Group

$$\begin{aligned} Q^D_{M,t} = {} & \Psi_0 + \Psi_1 (P_{M,t} - P_{R,t}) + \Psi_2 (P_{M,t-1} - P_{R,t-1}) + \Psi_3 (S_{M,t-1} - D_{M,t-1}) \\ & + \Psi_4 Y_t + \Psi_5 Y_{t-1} + \Psi_6 K_{t-1} + \Psi_7 M_{t-1} \\ & + \Psi_8 Q^D_{M,t-1} \end{aligned} \tag{4-2}$$

(3) World Demand

$$D_{M,t} = \sum^{j} Q^D_{M,t} \tag{4-3}$$

(4) Secondary Supply in a Specific Country Group

$$\begin{aligned} Q^{SCRAP}_{M,t} = {} & \phi_0 + \phi^P_1 P_{M,t} + \phi^P_2 P_{M,t-1} + \phi^P_3 P_{M,t-2} \\ & + \phi^D_1 Q^D_{M,t} + \phi^D_2 Q^D_{M,t-1} + \phi^D_3 Q^D_{M,t-2} + \phi^D_4 Q^D_{M,t-3} \\ & + \phi_3 Q^{SCRAP}_{M,t-1} \end{aligned} \tag{4-4}$$

(5) World Secondary Production

$$WQ^{SCRAP}_{M,t} = \sum^{j} Q^{SCRAP}_{M,t} \tag{4-5}$$

(6) Primary Supply in a Specific Country Group

$$\begin{aligned} Q^{S}_{M,t} = \theta_0 &+ \theta_1 P_{M,t} + \theta_2 P_{M,t-1} + \theta_3\, ROWS_{M,t-1} \\ &+ \theta_4 D_{M,t} + \theta_5 D_{M,t-1} + \theta_6 t \\ &+ \theta_7 r_t + \theta_8 r_{t-1} \\ &+ \theta_9 \sum^{t-1} Q^{S}_{M,i} + \theta_{10} Q^{S}_{M,t-1} \end{aligned} \tag{4-6}$$

(7) World Primary Production

$$S_{M,t} = \sum^{j} Q^{S}_{M,t} \tag{4-7}$$

In these, the exogenous variables are the world price of the related commodity (P_R) and country group specific values for the interest rate (r), income (Y), the rate of capital accumulation ($\dot{K}$), and the rate of growth of the money supply ($\dot{M}$).

To perform our simulations, we first must obtain future values for the exogenous variables via extrapolation. For each of the exogenous variables, we calculated the mean historical rate of growth (straight line), $\bar{P}_R$, $\bar{r}$, $\bar{Y}$, $\bar{K}$, and $\bar{M}$. Then, the t+1 values (e.g., 1977 values) will be extrapolated as

$$\tilde{P}_{R,t+1} = (1 + \bar{P}_R)\, P_{R,t} \tag{4-8}$$

$$\tilde{r}_{t+1} = (1 + \bar{r})\, r_t \tag{4-9}$$

$$\tilde{Y}_{t+1} = (1 + \bar{Y})\, Y_t \tag{4-10}$$

$$\tilde{K}_{t+1} = \bar{K} \tag{4-11}$$

$$\tilde{M}_{t+1} = \bar{M} \tag{4-12}$$

We then turn to our simulations of the variables under consideration. We first simulate the 1977 price using the extrapolated values for income, the interest rate, and the price of the related commodity in 1977 and existing values (i.e., 1975 and 1976 values) for the remainder of the variables in equation (4-1). Next, we use equation (4-2) to simulate consumption in 1977 in each of the country groups. In this, we must use our extrapolated income in 1977 and our *simulated* price in 1977 as data. Summing over the country groups, equation (4-3), we obtain simulated world consumption in 1977. Then, we use as data our simulated 1977 values for both price and consumption, as well as existing data for 1974, 1975, and 1976, in equation (4-4) to obtain a simulated value for scrap production in 1977 in each country group. Again summing over the country groups, equation (4-5), we obtain simulated world scrap production. To simulate primary production in 1977 in each country group, we employ existing 1976 data, the extrapolated value of the interest rate in 1977, and our simulations of price and world consumption in 1977 in equation (4-6). Then, we simulate world primary production in 1977 by summing over the country groups, equation (4-7).

To obtain simulations for 1978, the preceding steps will be reaccomplished. However, there is one major difference. The 1978 simulations will require, as data, the 1977 values for the variables under consideration. Since these values are not available, we use as the existing 1977 values our simulated values for 1977. Again, the iterative feature of our model is that we simulate the values in period t and then use these simulations as data to simulate the t+1 values. The 1977 simulations will be used as data in the 1978 simulations; then, the 1978 simulations will also be used in the 1979 simulations, and so on.

As the reader will note, there exists one primary difference between our simulation model and our econometric analysis. In the econometric analysis we estimated each of the functions individually. However, in the simulation model, we combine all of the individual functions into a simultaneous equations model. Given this simultaneity, it is then possible that some of the functions, as estimated individually, would be inappropriate in the simulation model. That is, while the function independently may be satisfactory, it could yield perverse results once it feeds into and receives feedback from the other equations in the system. Therefore, it may be necessary to change the specification of some of the individual functions.

In order to consider this difficulty, prior to performing the simulations of future values, we performed some in-sample predictions. We accomplished the procedures outlined in this section to predict the values over a known period, using alternative specifications of some of the individual equations. Specifically, we used the actual trends for the exogenous variables and the 1964 values for all of the variables to predict consumption, production and price for the period 1965-1977.[1] Then, by comparing our predicted values with the actual values, we selected those equations that provide the "best" simulation model, in the sense of providing those predicted values that most closely approximate the actual values. In the remainder of this section we present the necessary modifications.

4.2.a COPPER

Upon performing in-sample predictions to finalize the simulation model, it became apparent that changes in the econometric equations would be required. Changes were made in some of the primary production and demand equations, as well as the price equation.

In the case of primary production, alternate equations were estimated for South America, Europe, Oceania, and the Centrally Planned Economies. (The primary production equations for North America, Asia, and Africa remain as presented in Table 3-1). These alternate equations are displayed in Table 4-1. In these, the changes made were the exclusion of some of the explanatory variables.

With demand, all of the country groups were reestimated except South America and the Centrally Planned Economies. These equations are presented in Table 4-2. As the reader will note, the primary difference between these estimates and those presented in Table 3-3 is the inclusion of a dummy variable that takes on a value of one in 1975 and 1976 and is zero otherwise. This additional variable was included to reflect the effect of the recession that occurred during this period.

Our alternate price equation is as follows

$$
\begin{aligned}
P_{M,t} = {} & \underset{(-0.1500)}{-6.6342} + \underset{(1.0838)}{0.2523P_{M,t-1}} - \underset{(-0.0691)}{0.0162P_{M,t-2}} \\
& \underset{(-2.2577)}{-0.0292}\,(S_{M,t-1} + WQ^{SCRAP}_{M,t-1} - D_{M,t-1}) \\
& + \underset{(0.9633)}{0.9166t} + \underset{(0.0290)}{0.1234r_t} \\
& \underset{(-0.8487)}{-0.7767P_{R,t}} - \underset{(-0.3551)}{3.7819\ \text{Dummy}} \\
& R^2 = 0.6591 \qquad SEE = 8.7729
\end{aligned}
$$

---

[1] In essence, our in-sample prediction assumes that, in 1964, the growth rates for the exogenous variables over the period 1965-1977 were known with certainty. Using the 1964 values and the trends in the exogenous variables, we then simulate the values for production, consumption, and price for 1965 through 1977. It should be noted that none of actual values for this period are used; however, the econometric equations used included this period as data.

As the reader will note, substantial modifications were made. First, we changed our inventory variable from the difference between lagged primary production and consumption to the once lagged value of primary *plus* scrap production minus consumption. It was felt that this formulation more accurately reflects inventory behavior. Second, it was found that the price equation performed better (in the context of in-sample predictions) if the sum of past production, lagged price of aluminum, and current income were excluded. Finally, we again included a dummy variable to reflect the recessionary effects in 1975 and 1976.

4.2.b ALUMINUM

The results of our in-sample predictions indicated that some of the equations would have to be modified. As was the case with copper, changes were required in primary production, demand, and the price equation.

In the case of primary production, alternative equations were estimated for North America, South America, Asia, and Africa. These equations are presented in Table 4-3. In these, variables that proved to be inappropriate in the simulation model were eliminated.

For demand, only the equation for North America was reestimated. The results of this estimation are as follows

$$
\begin{aligned}
Q^D_{M,t} = {} & \underset{(-8.5909)}{-5287.82} - \underset{(-1.4754)}{7.4294}(P_{M,t} - P_{R,t}) + \underset{(2.2405)}{11.5189}(P_{M,t-1} - P_{R,t-1}) \\
& + \underset{(9.0624)}{9234.44}Y_t + \underset{(0.4614)}{0.0537}Q^D_{M,t-1} - \underset{(-3.7794)}{783.560}\,\text{Dummy}
\end{aligned}
$$

$$R^2 = 0.9827 \qquad \text{SEE} = 200.530$$

In this, some of the explanatory variables were eliminated and a dummy variable was added to account for the recessionary effects of 1975-1976. The alternative price equation was estimated as follows

$$
\begin{aligned}
P_{M,t} = {} & \underset{(3.3400)}{16.8802} + \underset{(4.6839)}{1.0090}P_{M,t-1} - \underset{(-1.8692)}{0.3765}P_{M,t-2} \\
& + \underset{(0.0697)}{0.00007}\,(S_{M,t-1} + WQ^{SCRAP}_{M,t-1} - D_{M,t-1}) \\
& + \underset{(2.5799)}{1.1989}r_t + \underset{(1.6286)}{0.0458}P_{R,t} - \underset{(-2.1385)}{17.8384}Y_t
\end{aligned}
$$

$$R^2 = 0.7959 \qquad \text{SEE} = 1.1252$$

As with copper, we changed the inventory variable to include scrap. Furthermore, several of the explanatory variables reported in Table 3-8 proved unsatisfactory in the context of the simulation model and were eliminated.

4.2.c NICKEL

As a result of our in-sample predictions, it became necessary to alter several of our estimated equations. These changes were necessary for primary production, demand, and the price equation.

In the case of primary production, alternate equations were estimated for North America, South America, Africa, Oceania, and the Centrally Planned Economies. These equations are presented in Table 4-4. For North America, the current interest rate was eliminated. For South America, two dummy variables were included. The first of these reflects the fact that, after 1962, production from Cuba was included in the figures for the Centrally Planned Economies.[2] The second reflects the increased production in South America in 1972 and beyond.[3] For Africa, we excluded current price and added a dummy variable to reflect the increase in production that began in 1970.[4] For Oceania, a dummy variable was added to reflect the increased production beginning in 1968.[5] Finally, for the Centrally Planned Economies, a dummy variable was again added to reflect the fact that, after 1962, Cuban production was reported as part of the Centrally Planned Economies.[6]

In the case of demand, alternate equations were estimated for North America, Africa, Europe, Oceania, and the Centrally Planned Economies. These equations are presented in Table 4-5. For North America, we added a dummy variable to reflect the recessionary effects of 1975-1976.[7] For Africa, we reformulated our equation, eliminating the inventory variable and the rate of growth of the capital stock. For Europe, we eliminated current prices and added the dummy variable for the recession of 1975-1976. In Oceania, we added lagged prices and our inventory variable and again included the dummy variable to reflect the recessionary effects of 1975-1976. Finally, for the Centrally Planned Economies, we added a dummy variable to reflect the increase in consumption in 1963 and beyond.[8]

Our alternate price equation was estimated as follows

$$
\begin{aligned}
P_{M,t} = {} & \underset{(2.1022)}{25.9284} + \underset{(3.7275)}{0.8082}P_{M,t-1} - \underset{(-0.9482)}{0.1853}P_{M,t-1} \\
& - \underset{(-0.5406)}{0.0140}\,(S_{M,t-1} + WQ^{SCRAP}_{M,t-1} - D_{M,t-1}) \\
& + \underset{(3.1869)}{5.1756}r_t + \underset{(2.1822)}{0.5195}P_{R,t} - \underset{(-3.1030)}{0.7244}P_{R,t-1} \\
& + \underset{(0.0429)}{0.8189}Y_t \\
& R^2 = 0.9638 \qquad \text{SEE} = 3.8952
\end{aligned}
$$

We again changed our inventory variable to include scrap. Further, we eliminated some variables reported in Table 3-12 that proved unsatisfactory in the context of the simulation model.

---

[2] The dummy variable is equal to one in 1963-1976 and zero otherwise.

[3] The dummy variable is equal to one in 1972-1976 and zero otherwise.

[4] The dummy variable is equal to one in 1970-1976 and zero otherwise.

[5] The dummy variable is equal to one in 1968-1976 and zero otherwise.

[6] See footnote 2.

[7] The dummy variable is equal to one in 1975-1976 and zero otherwise.

[8] See footnote 2.

Using this model, we performed an in-sample prediction for the period 1965-1977. We then proceeded to simulate the future values of production, consumption, and price for nickel. While our in-sample predictions proved to be quite satisfactory, the future simulations proved to be somewhat disquieting — particularly in the case of primary production in North America. Our predictions indicate that North American production will peak in the early 1980's and decline thereafter. Although this situation is plausible, we felt that it deserved some additional consideration.

We were made aware of the assertion that the nickel market is one in which there has existed a dominant firm price leader and that the price leader is located in North America. Indeed, our econometric estimates were consistent with this contention. In such a situation, our future simulations are more understandable. Faced with increased production in the rest of the world, the profit-maximizing dominant firm will reduce output. Thus, in the context of our future simulations, if production in the rest of the country groups increases (as is projected), production in North America would be expected to decline.

However, with this increased production in the rest of the world, we would expect the market power of the dominant firm to decline, thereby reducing its ability to set price. It would then be most useful to have simulations of the future conditions in the nickel market, assuming that the market evolves into a more competitive structure. Obviously, the problem exists that we can not estimate such an alternative structure, since the available historical data incorporates the price leadership behavior. We can, however, use some accepted theoretical principles to modify our estimated equations.

We expect the influences of a price leader to appear in two equations, the supply function for the dominant country group (North America) and the price equation. Let us begin with the primary production equation for North America. As we have argued earlier, the dominant firm will be more responsive to supply from the rest of the world than would be the other suppliers. This is confirmed in our estimates by comparing the estimate of θ_3 in North America with those for the other country groups. Furthermore, it is only the dominant firm that will be concerned with the world (market) demand. This is supported by the fact that the estimates of θ_4 and θ_5 are larger for North America than for the other country groups. Therefore, to indicate an elimination of the price leadership behaviour, the coefficients θ_3, θ_4 and θ_5 must be altered. In our modified simulation, we assume that North America will behave more like Oceania (another large producer of nickel) in the future. Hence, we will employ, in our modified primary production equation for North America, the Oceania estimates for θ_3, θ_4, and θ_5.[9]

The price equation as estimated is generally satisfactory. However, we would normally expect price to be more sensitive to changes in inventories in a competitive market than in one characterized by price leadership. Therefore, in our modified simulation, we changed this coefficient (η_3) to the one estimated for the copper market. That is, we changed η_3 from -0.0140 to -0.0292.[10]

We made one additional change in our modified simulation model. As the reader will note from Table 4-5, the sign of the coefficient for the lagged difference between primary production and consumption (Ψ_3) is opposite of that predicted theoretically for North America, Europe, and Oceania. Since all of the estimated coefficients are statistically insignificant, we set them equal to zero.

---

[9] Note that these values are within the 95% confidence interval of the original estimates for North America.

[10] Note from our estimates that -0.0292 is within the 95% confidence interval of the estimated value of η_3 for nickel.

4.2.d ZINC

Again, we performed several in-sample predictions. The results of these simulations indicated that modifications were required in primary production, demand, and the price equation.

For primary production, only the equation for Africa was reestimated. The results of this estimation are as follows

$$
\begin{aligned}
Q^{S}_{M,t} = {} & \underset{(-3.4465)}{-4582.93} + \underset{(1.8274)}{2.7020}P_{M,t-1} - \underset{(-1.6103)}{0.0288}ROWS_{M,t-1} + \underset{(1.4854)}{0.0222}D_{M,t-1} \\
& + \underset{(3.5444)}{94.5641}t - \underset{(-3.5181)}{0.3663}\sum^{t-2} Q^{S}_{M,i} - \underset{(-0.2788)}{0.0614}Q^{S}_{M,t-1}
\end{aligned}
$$

$$R^2 = 0.6354 \qquad SEE = 16.3408$$

As should be noted, the primary change in this formulation is the elimination of the twice lagged terms for price and world consumption.

In the case of demand, alternative equations were estimated for North America, South America, Asia, Europe, and Oceania. These equations are presented in Table 4-6. In these, the only change made was the inclusion of a dummy variable to reflect the recessionary effects of 1975-1976.[11]

The alternative price equation was estimated as

$$
\begin{aligned}
P_{M,t} = {} & \underset{(2.3921)}{84.9847} + \underset{(3.8991)}{0.5423}P_{M,t-1} - \underset{(-1.0041)}{0.2490}P_{M,t-2} \\
& - \underset{(-1.3690)}{0.0026}(S_{M,t-1} + WQ^{SCRAP}_{M,t-1} - D_{M,t-1}) \\
& - \underset{(-3.6834)}{1.4996}t - \underset{(-0.8571)}{0.7031}r_t - \underset{(-1.9877)}{0.0005}\sum^{t-2} S_{Mi} \\
& + \underset{(0.9366)}{0.1216}P_{R,t} - \underset{(-2.8532)}{0.2720}P_{R,t-1} + \underset{(2.5436)}{0.1989}P_{R,t-2} \\
& - \underset{(-0.0381)}{0.5750}Y_t
\end{aligned}
$$

$$R^2 = 0.9208 \qquad SEE = 1.7332$$

Comparing these estimates with those presented in Table 3-16, the only differences are the reformulation of the inventory variable to include scrap and the inclusion of the current price of the related commodity (steel).

---

[11] The dummy variable is equal to one in 1975-1976 and zero otherwise.

TABLE 4-1
SIMULATION EQUATIONS
PRIMARY PRODUCTION
COPPER
(T-STATISTICS IN PARENTHESES)

		North America	South America	Asia	Africa	Europe	Oceania	Centrally Planned
θ_0	Constant		-1217.08 (-1.4625)			-12.5699 (-0.5564)	-48.0941 (-1.4994)	-239.1120 (-1.4600)
θ_1	$P_{M,t}$		0.3697 (0.2732)					
θ_2	$P_{M,t-1}$		-1.6621 (-1.3534)			0.0511 (0.1573)		1.1908 (2.7388)
θ_3	$ROWS_{M,t-1}$						0.0203 (0.4822)	
θ_4	$D_{M,t}$					0.0079 (1.0276)	0.0270 (1.3130)	
θ_5	$D_{M,t-1}$					-0.0027 (-0.2768)	-0.0299 (-1.1052)	
θ_6	t		32.8896 (1.8247)					4.3026 (1.3226)
θ_7	r_t		NA					NA
θ_8	r_{t-1}		NA					NA
θ_9	$\overset{t-2}{\Sigma} Q^S_{M,i}$		-0.0039 (-0.2295)			-0.0064 (-0.3577)		-0.0034 (-0.2731)
θ_{10}	$Q^S_{M,t-1}$		0.0578 (0.2034)			0.9336 (5.4435)	0.8542 (5.9984)	0.9898 (5.4467)
	R^2		0.9553			0.9349	0.9492	0.9974
	SEE		54.3194			10.1128	31.2419	23.2695

TABLE 4-2
SIMULATION EQUATIONS
DEMAND
COPPER
(T-STATISTICS IN PARENTHESES)

		North America	South America	Asia	Africa	Europe	Oceania	Centrally Planned
Ψ_0	Constant	-263.821 (-1.0611)		-761.783 (-1.7666)	-79.0716 (-3.1606)	-100.226 (-0.5779)	-71.7731 (-2.9213)	
Ψ_1	$P_{M,t}-P_{R,t}$					-0.3387 (-0.0826)		
Ψ_2	$P_{M,t-1}-P_{R,t-1}$	-3.7993* (-1.1372)		-2.1243 (-0.8245)	-0.2709 -1.5337)	-10.9103 (-3.0553)	-0.3493 (-1.7803)	
Ψ_3	$S_{M,t-1}-D_{M,t-1}$	-0.2163 (-1.1011)			0.0060 (0.6998)	-0.1660 (-0.7104)	-0.0131 (-1.1697)	
Ψ_4	Y_t	5367.68 (4.4569)		1457.17 (0.6360)	1.2502 (0.0249)		244.232 (3.0878)	
Ψ_5	Y_{t-1}	-3488.63 (-2.3346)		448.012 (0.1510)	117.147 (1.8436)	2390.87 (4.0990)	-99.0476 (-0.9477)	
Ψ_6	$\dot{K}_{t-1}$	64.1942 (0.0678)		1056.26 (1.3035)	-93.5441 (-2.5877)	2330.78 (2.4035)	106.307 (2.2385)	
Ψ_7	$\dot{M}_{t-1}$	6.6888 (0.3343)		NA	NA	-10.6219 (-0.8430)	-0.2543 (-0.8355)	
Ψ_8	$Q^D_{M,t-1}$	0.1313 (0.4154)		-0.3964 (-0.7341)	0.8346 (6.3630)	0.0986 (0.4272)	0.2847 (1.2786)	
	Dummy Variable	-274.550 (-1.5206)		-427.871 (-1.5254)	-20.1522 (-2.8066)	-17.8323 (-0.1065)	-8.9993 (-1.0056)	
	R^2	0.9274		0.9318	0.9835	0.9627	0.9735	
	SEE	126.430		98.8461	3.7292	108.332	5.9820	

* Estimated coefficient for $P_{M,t-2}-P_{R,t-2}$

TABLE 4-3
SIMULATION EQUATIONS
PRIMARY PRODUCTION
ALUMINUM
(T-STATISTICS IN PARENTHESES)

		North America	South America	Asia	Africa	Europe	Oceania	Centrally Planned
θ_0	Constant	-559.148 (-1.2873)	-84.8237 (-2.2810)	-255.296 (-1.7846)	-82.5312 (-0.9231)			
θ_1	$P_{M,t}$	44.8745 (2.2249)	5.9285 (2.2910)					
θ_2	$P_{M,t-1}$	2.8725 (0.1634)	-3.1798 (-1.3588)	8.3518 (1.3579)	1.8953 (0.5965)			
θ_3	$ROWS_{M,t-1}$	-0.5353 (-4.3538)						
θ_4	$D_{M,t}$	0.3532 (9.6504)	0.0056 (2.0320)		0.0092 (2.3453)			
θ_5	$D_{M,t-1}$	0.3824 (4.4876)		0.0286 (1.9423)				
θ_6	t							
θ_7	r_t		NA	NA	NA			
θ_8	r_{t-1}		NA	NA	NA			
θ_9	$\sum^{t-2} Q^{S}_{M,i}$	-0.0042 (-0.2967)	0.0188 (0.7093)					
θ_{10}	$Q^{S}_{M,t-1}$	-0.0933 (-0.5025)	0.8048 (3.7668)	0.8414 (7.3740)	0.8017 (5.4352)			
	R^2	0.9957	0.9875	0.9885	0.9693			
	SEE	95.5451	12.7906	59.2330	19.2582			

TABLE 4-4
SIMULATION EQUATIONS
PRIMARY PRODUCTION
NICKEL
(T-STATISTICS IN PARENTHESES)

		North America	South America	Asia	Africa	Europe	Oceania	Centrally Planned
θ_0	Constant	-857.182 (-1.1690)	84.8718 (0.6417)		75.7832 (4.2018)		-32.4291 (-0.1727)	-80.4032 (-1.3042)
θ_1	$P_{M,t}$	1.3088 (0.4487)					1.4465 (0.7011)	1.4350 (3.0462)
θ_2	$P_{M,t-1}$	-0.4006 (-0.2417)	0.2931 (0.7832)		0.3381 (2.8395)		-0.1159 (-0.1389)	-1.0362 (-2.9882)
θ_3	$ROWS_{M,t-1}$	-0.3506 (-0.5593)	-0.0698 (-1.4467)		-0.0049 (-0.3899)		-0.0219 (-0.0800)	0.1397 (2.6337)
θ_4	$D_{M,t}$	0.2007 (0.7790)	0.0757 (1.3019)		0.0328 (2.3078)		0.1373 (0.8640)	0.0555 (0.8576)
θ_5	$D_{M,t-1}$	0.3220 (1.7191)	0.0811 (1.2357)		0.0353 (1.5477)		0.1978 (1.9718)	-0.0205 (-0.4220)
θ_6	t	17.2693 (1.0703)	-2.0665 (-0.6873)		-2.0038 (-4.2930)		-3.4541 (-0.5651)	0.9874 (0.7320)
θ_7	r_t		NA		NA		11.3332 (1.4397)	NA
θ_8	r_{t-1}	10.5975 (0.4740)	NA		NA		9.3204 (0.6719)	NA
θ_9	$\sum^{t-2} Q^S_{M,i}$	-0.0873 (-0.7376)	0.0592 (0.5823)		0.2845 (6.6761)		-0.0364 (-1.2312)	-0.0492 (-2.8258)
θ_{10}	$Q^S_{M,t-1}$	-0.2648 (-1.0763)	0.3593 (2.4180)		-0.6650 (-2.3848)		-0.1474 (-0.5944)	0.4289 (3.0496)
	Dummy 1		-21.4206 (-2.7258)		7.3781 (2.5837)		38.7820 (1.0715)	37.0951 (4.8074)
	Dummy 2		34.2518 (4.5041)					
	R^2	0.8703	0.9474		0.9918		0.9886	0.9865
	SEE	25.1435	6.5956		1.5668		9.6666	6.5040

TABLE 4-5
SIMULATION EQUATIONS
DEMAND
NICKEL
(T-STATISTICS IN PARENTHESES)

		North America	South America	Asia	Africa	Europe	Oceania	Centrally Planned
Ψ_0	Constant	-90.9912 (-2.1983)			-2.1142 (-0.5566)	-122.367 (-4.5159)	-9.2509 (-6.6680)	4.9018 (0.8933)
Ψ_1	$P_{M,t}-P_{R,t}$							-0.3387 (-1.1584)
Ψ_2	$P_{M,t-1}-P_{R,t-1}$	-0.8062 (-1.2435)				-0.4728 (-1.0191)	-0.0222 (-1.0658)	-0.2333 (-0.8251)
Ψ_3	$S_{M,t-1}-D_{M,t-1}$	-0.1138 (-1.2219)				-0.0792 (-1.1374)	-0.0023 (-0.8358)	0.0116 (0.3796)
Ψ_4	Y_t	294.110 (2.2826)			1.3058 (0.1302)	374.079 (2.1062)	7.1330 (1.3136)	-3.9232 (-0.0423)
Ψ_5	Y_{t-1}	-26.5808 (-0.1654)			2.0994 (0.2195)	-51.5532 (-0.2514)	7.8341 (1.2450)	52.3432 (0.5300)
Ψ_6	K_{t-1}	59.8842 (0.7781)				9.9632 (0.1380)	1.4668 (0.5303)	NA
Ψ_7	M_{t-1}	0.5157 (0.2585)			NA	-0.5350 (-0.5299)	0.0159 (0.8428)	NA
Ψ_8	$Q^D_{M,t-1}$	-0.0431 (-0.1854)			0.7314 (3.2301)	-0.2065 (-0.8248)	-0.4507 (-2.6534)	0.5419 (2.8997)
	Dummy	-24.0216 (-1.4907)				-23.8646 (-1.6657)	-2.3437 (-4.2755)	13.3891 (1.8258)
	R^2	0.9134			0.8577	0.9759	0.9400	0.9852
	SEE	12.0044			6.3311	9.6802	0.4344	5.5125

TABLE 4-6
SIMULATION EQUATIONS
DEMAND
ZINC
(T-STATISTICS IN PARENTHESES)

		North America	South America	Asia	Africa	Europe	Oceania	Centrally Planned
Ψ_0	Constant	44.5529 (0.3241)	-384.534 (-2.4679)	-525.291 (-1.1813)		-239.372 (-2.4221)	-68.1776 (-4.9736)	
Ψ_1	$P_{M,t}-P_{R,t}$	-2.8987 (-0.4529)						
Ψ_2	$P_{M,t-1}-P_{R,t-1}$	3.2183 (0.5877)	-0.4698 (-0.4336)	-5.9813 (-1.1433)		-5.9412 (-3.2647)	-0.7599 (-3.4063)	
Ψ_3	$S_{M,t-1}-D_{M,t-1}$	-0.0617 (-0.6717)	-0.0103 (-0.5314)	0.1954 (2.2111)		-0.0641 (-0.7181)	-0.0113 (-1.6917)	
Ψ_4	Y_t	4343.40 (4.3450)	410.939 (2.1196)	-138.384 (-0.0684)		2617.49 (2.9331)	55.9709 (0.7692)	
Ψ_5	Y_{t-1}	-3860.77 (-3.8497)	185.553 0.5918)	544.953 (0.2299)		-1262.81 (-1.1551)	113.669 (1.3978)	
Ψ_6	K_{t-1}	-618.125 (-1.1369)	-33.0869 (-0.6330)	609.878 (1.4155)		560.746 (1.3412)	27.5280 (0.7537)	
Ψ_7	M_{t-1}	-2.0851 (-0.1151)	NA	NA		1.4573 (0.3024)	0.0684 (0.2803)	
Ψ_8	$Q^D_{M,t-1}$	0.5883 (2.2688)	-0.4558 (-0.5905)	0.5036 (1.3728)		-0.1176 (-0.4011)	-0.3237 (-1.8943)	
	Dummy	-247.563 (-2.8101)	-39.9537 (-2.7306)	-304.438 (-1.5378)		-237.739 (-3.7576)	-36.3902 (-5.4583)	
	R^2	0.9309	0.9913	0.9783		0.9859	0.9651	
	SEE	71.4528	7.2848	47.6761		43.8874	5.6811	

4.3 EVALUATION OF THE SIMULATION MODEL

In the preceding sections, the simulation model developed in *An Econometric and Simulation Approach to the World Mineral Markets* has been described. However, the question that should be foremost in the minds of potential users is: "How well does the model perform?" In this section, that question will be addressed by comparing some of the forecasts contained in this earlier manuscript with the actual values of world production, consumption and price for the period 1977-1979. (Note that the earlier manuscript was based on the period 1952-1976).

In the earlier manuscript, seven simulations were performed for each of the mineral commodities. These included a base simulation and alternative scenarios concerning the growth rates of the exogenous variables and exogenous shocks to production. It would appear that, over the period 1977-1979, there have been no substantial exogenous shocks; so, the selection of the "most appropriate" simulation would be based upon a comparison of the actual and assumed growth rates of the exogenous variables. Data for these variables are available only for 1977. The growth rates are displayed in Table 4-7.

TABLE 4-7
ACTUAL GROWTH RATES OF THE EXOGENOUS VARIABLES - 1977

	Income	Capital	Interest Rate	Growth Rate of Money Supply
North America	2.86	8.49	7.77	7.20
South America	1.96	4.85	N/A	N/A
Asia	1.89	13.99	N/A	N/A
Africa	1.96	4.76	N/A	N/A
Europe	1.92	0.98	8.78	9.17
Oceania	0.97	1.98	10.14	7.65
Centrally Planned	3.85	N/A	N/A	N/A

TABLE 4-8
HYPOTHESIZED GROWTH RATES OF THE EXOGENOUS VARIABLES — SIMULATION #2

	Income	Capital	Interest Rate	Growth Rate of Money Supply
North America	0.10	-2.40	8.39	5.02
South America	1.20	2.10	N/A	N/A
Asia	2.80	5.80	N/A	N/A
Africa	-0.60	3.30	N/A	N/A
Europe	1.40	0.20	10.11	8.70
Oceania	0.60	0.60	10.42	7.40
Centrally Planned	3.90	N/A	N/A	N/A

With respect to the rate of growth of income, the following results are obtained: For North America, simulation #0 provides the best approximation. For Africa, simulation #0 again provides the best approximation. However, for the remainder of the country groups, simulation #2 provides the best approximation. Thus, in respect to this variable, simulation #2 may be regarded as the "most appropriate". However, it would be expected that such a simulation will underpredict consumption, particularly in North America and Africa.

With respect to the rate of capital accumulation, the following results are obtained: In the case of North America, simulation #1 provides the best approximation. For Africa, the best approximation is obtained using simulation #0. For the remainder of the country groups, the best approximation is that under simulation #2. Thus, it would again appear that simulation #2 is "most appropriate". But, this simulation would again underpredict consumption, particularly in North America and Africa.

The interest rates and rates of growth of the money supplies were not altered in these simulations. Therefore, on the basis of the preceding, it would appear that simulation #2 is "most appropriate". However, it should be noted that the hypothesized interest rates and rates of growth of the money supplies are higher than the actual values.

The hypothesized values for the exogenous variables in simulation #2 are presented in Table 4-8. While the simulated values from this scenario will be compared to the actual values, it should be noted again that such a model would be expected to underpredict the consumption values, particularly for North America and Africa. Given these caveats, the remainder of this section will deal with the comparison of the actual and predicted values (using simulation #2) for production, consumption, and price for the minerals under consideration for the period 1977-1979.

In essence, this discussion assumes that, in 1976, the user wished to forecast the values of production, consumption, and price for the period 1977-1979. If the user felt that the historical growth rates of income and capital formation were too high, a simulation like simulation #2 — in which the growth rates are assumed to be one standard deviation below trend — would have been appropriate. By comparing the predicted values with actual values, some idea of the quality of future forecasts can be obtained.

4.3.a COPPER

Using simulation #2, the mean percentage errors and the root mean percentage errors for the world values are as displayed in Table 4-9. It should be noted that primary production, secondary production, and consumption all are within a 5% average error interval. The error for price is much greater; but, this relatively poor performance is most probably due to the poor "fit" of the estimated price equation. Since the R^2 value for this equation is 0.66, approximately 34% of the variation in price is unexplained. Note that this 34% unexplained variation corresponds very closely with the 34.52% mean percentage error.

TABLE 4-9
COPPER ERRORS

	Mean Percentage Error	Root Mean Percentage Error
Primary Production	0.49	1.42
Secondary Production	-3.91	5.37
Consumption	-4.96	5.52
Price	34.52	37.41

Hence, on the world level, the predictions for primary production, secondary production, and consumption are extremely satisfactory. Although the price predictions are less precise, they are understandable.

On the level of specific country groups, the forecasts obtained from simulation #2 were again quite satisfactory. Primary production is overpredicted in Africa and underpredicted in South America. This error seems to be the result of changes in trend in recent years. For secondary production, South America is overpredicted and Asia is underpredicted. In the case of Asia, this result may be due to the underprediction of consumption inherent in simulation #2. (See above) Consumption is underpredicted in both North America and Asia. However, as noted earlier, the growth rates of income and capital are too low in simulation #2; so, this error is expected.

4.3.b ALUMINUM

The actual values of world production, consumption, and price for the period 1977-1979 were compared with the values predicted by simulation #2. The results of this comparison are displayed in Table 4-10.

TABLE 4-10
ALUMINUM ERRORS

	Mean Percentage Error	Root Mean Percentage Error
Primary Production	0.20	1.17
Secondary Production	-12.95	13.34
Consumption	-7.10	7.64
Price	-4.07	5.23

On this the world level, the predictions for primary production, consumption, and price are all quite good. While the prediction for secondary production is not as satisfactory, the error is still less than 15%. These results are even more satisfactory when one remembers that simulation #2 incorporated growth rates for income and capital that were too low. This underestimation of the growth rates explains the underprediction of consumption, which, in turn, explains the underestimates for secondary production and price.

On the level of the specific country groups, the results were also quite satisfactory. Primary production was underpredicted in both North America and South America; but, given the underprediction of consumption, this is not surprising. As expected, consumption was underpredicted in several country groups due to the incorrect assumptions about the growth rates of the exogenous variables. This underprediction of consumption led to an underprediction of secondary production in several country groups. Only in Oceania was secondary production overpredicted.

4.3.c NICKEL

The results of the comparison of the world nickel data for the period 1977-1979 with the predicted values from simulation #2 are summarized in Table 4-11. Since reported nickel scrap recovery is so small relative to primary production and consumption, attention will be limited to primary production, consumption, and price.

TABLE 4-11
NICKEL ERRORS

	Mean Percentage Error	Root Mean Percentage Error
Primary Production	18.47	21.63
Consumption	-4.05	8.25
Price	12.54	16.25

In the case of primary production, simulation #2 overpredicted output in North America, South America (substantially), and Oceania, while underpredicting in the centrally planned economies. With respect to the errors in South America and the centrally planned economies, the cause of the error lies in the data. In the data set employed in the estimations (1952-1976), Cuba was included in South America. However, in the 1977-1979 data, Cuba is included in the centrally planned economies. (This change has been incorporated in the computer simulation model described in Part II of this monograph.) The overprediction of primary production in North America is due to the strike of a major producer that reduced output in 1978 and 1979. Thus, the primary production estimates are actually much more satisfactory than would first appear.

The underprediction of consumption (particularly in Europe and Oceania) is most likely the result of the inaccurate estimates of the growth rates of the exogenous variables. As has been noted, simulation #2 underestimates the growth rates of income and capital.

The large error in the prediction of the price of nickel was the result of a sharp decrease in price in 1978. The real price of nickel (constant 1967 U.S. dollars, showed the following behavior:

1976	123.09
1977	123.68
1978	99.90
1979	115.24

While no specific explanation is proposed, the reader should review the specific features of the nickel market and the potential for a change in market structure that were discussed in *An Econometric and Simulation Approach to the World Mineral Markets.*

4.3.d ZINC

The results of the comparison of the actual and simulated values for zinc are summarized in Table 4-12. Secondary production is excluded because there was a major revision in this series and because scrap recovery makes up a relatively small percentage of total production.

TABLE 4-12
ZINC ERRORS

	Mean Percentage Error	Root Mean Percentage Error
Primary Production	-4.95	5.22
Consumption	-9.63	10.56
Price	66.25	70.55

Of all of the minerals considered, the zinc results are the least satisfactory. Both production and consumption are well within a 10% error range; but, the price simulations have an average error of 66%.

The underprediction of consumption was caused primarily by underpredictions for North America, South America and Asia. (Consumption was overpredicted for Oceania.) As has been noted above, such underprediction of consumption is expected using simulation #2, since this scenario underestimated the growth rates of income and capital.

The underprediction of primary production was primarily the result of the underprediction of output from North America. Two factors could have been responsible for this error. First, given the estimated North America demand function for zinc, an underprediction of consumption (noted above) would yield an underprediction of primary production. Second, U.S. output has declined recently as a result of the closing of some zinc mines.

No specific justification for the errors in the price forecasts can be provided. However, it should be noted that the estimated zinc price equation is much more sensitive to changes in world inventories than are the price equations for the other mineral commodities considered. Thus, the errors in the prediction of production and consumption could explain the prediction errors in price. Also, it could be the case that there has been a change in structure in this market

Overall, it would appear that if, in 1976, one had posited a general decline in the growth rates of income and capital accumulation and had used the simulation model described in this monograph to predict production, consumption, and price over the period 1977-1979, fairly accurate forecasts would have been obtained. However, these results also point to the need for fairly frequent updates of the model. Since changes of structure may be expected, the econometric model probably should be reestimated every 2-3 years, as additional data becomes available.

PART II
THE SIMULATION PROCEDURES

- 5 -

AN OVERVIEW OF THE SIMULATION PROGRAM

In this chapter, an introduction to the simulation program will be provided. This discussion will be very general. The specific procedures required to obtain simulations will be presented in Chapter 6. The reader interested in the more technical aspects of the program itself is referred to the appendices to this monograph.

The program contains models for the copper, aluminum, nickel, and zinc markets (as well as a modified model of the nickel market). These models are made up of from 16 to 21 equations. For every mineral, there are primary production and demand functions for each of the country groups (14 equations) and a price equation. In the case of copper, there are five secondary (scrap) production functions. The aluminum model contains six secondary production equations, while both nickel and zinc use only one secondary production function. Finally, for every mineral, there is a price equation. These functions, as well as the estimated parameters, are presented in Chapters 3 and 4.

To obtain simulations of the future values of production, consumption, and price, these models require, as data, historical values of production and consumption by country group and world price and the future values of the exogenous variables. Although the individual functions were estimated using data for the period 1952-1976, the simulation models will incorporate the most recent available data. Specifically, the simulation program contains the 1979 values for production, consumption, and price. These values are presented in Table 5-1.[1] In this model, the future values for the exogenous variables are predicted using historical trend (i.e., extrapolated). The exogenous variables used are the country group specific values for income, the interest rate, the rate of growth of the money supply, and the rate of capital accumulation, as well as the world price of the related commodity for each mineral. In this study, copper and aluminum were treated as substitutes; aluminum is the related commodity for copper and vice versa. For both nickel and zinc, raw steel was used as the related commodity. In the "base simulation" (described below), it is assumed that the exogenous variables follow the historical trend established over the period 1962-1977. The growth rates over this period are presented in Table 5-2. Note, however, that the interest rates and the rates of growth of the money supplies are simply the averages over the period. Since these variables are entered as percentages, the historical average is more appropriate than the rate of growth in this percentage.

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[1] From this table and the discussion in Chapter 4, it is obvious that some major revisions have been made in the data set. In order to accomodate these changes, the following modifications were made:
Copper: The actual price in 1979 was 92.91 cents per pound. As discussed in Chapter 4, it is felt that this price was abnormally high; so, using an annual growth rate of 3.55% a price of 83.10 cents per pound was used. To adjust for the difference in the sample mean and the initial values of the inventory variable, the following revisions were made: In the price equation, the intercept was changed to -39.4161. In individual demand equations, the intercept was altered to -493.821 in North America, -593.065 in South America, -280.226 in Europe, -86.7731 in Oceania, and -43.5509 in the centrally planned economies.
Nickel: To accomodate the revisions made in the primary production data for South America and the centrally planned economies, the intercepts in these country groups were lowered and raised, respectively, by 34.2518.
Zinc: Due to the changes made in the scrap data, the intercept in this equation was reduced from 168.399 to 118.399. The change in the price series was incorporated by lowering the intercept in the price equation from 84.9847 to 74.9847.

Once the historical values of production, consumption, and price and the growth rates of the exogenous variables are entered, the simulation proceeds as described in Chapter 4. Using the actual 1979 values of production, consumption, and price and the extrapolated values for income, the capital stock, the interest rate, and the rate of growth of the money supply in the particular country groups, as well as the extrapolated world price of the related commodity, the model predicts production, consumption, and price for the mineral under consideration in 1980. Then, using the extrapolated values for the exogenous variables and the *predicted* 1980 values for production, consumption, and price, the model predicts production, consumption, and price in 1981. This process continues using the extrapolated values for the exogenous variables in period t to predict the values for production, consumption, and price in period t + 1. An illustrative output is presented in Table 5-3. Note first that the model prints the assumed rates of growth of the exogenous variables. In this table, a value of 0.0 means that the growth rate is not available. Further, note that, in this output, "SUPPLY" denotes primary production and "DEMAND" denotes consumption, while secondary production is listed separately. Finally, note that the prices listed are *real* (i.e., deflated prices.) All prices are in terms of 1979 U.S. dollars.

TABLE 5-1
MINERAL DATA 1979

	COPPER	ALUMINUM	NICKEL	ZINC
Primary Production (Thousand metric tons)				
North America	2085.1	5420.5	142.5	1496.4
South America	1577.4	666.7	34.9	996.2
Asia	504.5	1460.0	70.6	413.5
Africa	1286.3	400.7	60.8	217.6
Europe	167.5	3424.8	22.5	871.4
Oceania	403.6	423.7	156.2	528.1
Centrally Planned	1742.5	3050.9	199.1	1500.8
Consumption (Thousand metric tons)				
North America	2479.0	5357.9	195.4	1154.1
South America	460.7	563.3	12.2	333.4
Asia	1592.2	2470.8	143.3	1222.0
Africa	94.3	150.6	5.4	122.4
Europe	2721.4	3707.5	230.4	1641.5
Oceania	129.1	223.0	5.3	118.7
Centrally Planned	2028.7	2928.1	171.1	1515.1
Secondary Production (Thousand metric tons)				
North America	495.9	1587.2	11.976	
South America	43.9	91.8	N/A	971.5
Asia	155.7	786.5	N/A	
Africa	N/A	16.0	N/A	
Europe	468.8	1202.9	N/A	
Oceania	35.5	47.5	N/A	
Price (1979 U.S. dollars)	83.10 (cents/lb.)	59.39 (cents/lb.)	271.50 (cents/lb.)	37.30 (cents/lb.)

The simulation program was designed so as to provide the user a maximum amount of flexibility. Not only can the user determine the period to be forecasted (up to a maximum of 25 years) but also the user can select from several types of alternative forecasts or combinations of these. Furthermore, the user can obtain plots (graphs) for any variable and country group (or the world).

The simplest type of forecast is referred to as the base simulation. In this simulation, all of the exogenous variables are assumed to follow historical trend. As will be described in Chapter 6, in order to obtain such a simulation, only one card — the control card — is required.

It is quite likely that some of the exogenous variables will deviate from their historical trends. For example, the rate of growth of income in Asia may be expected to be lower than that indicated historically. Thus, the program permits simulations using alternative growth rates for the exogenous variables. (The maximum number of alternative growth rates in a particular simulation is 25.) Such a simulation requires only the control card and one additional card for each growth rate that is to be altered.

It is also likely that non-market occurences can alter the production, consumption, or price of a mineral commodity. For instance, political instability in Africa could cause production of a particular mineral commodity to be, say, 10% below the level that would normally be forthcoming. The simulation program permits forecasts assuming this type of exogenous change (up to 20 changes per simulation). Such simulations require only the control card and one additional card for each exogenous change to be simulated.

An area of particular significance is the entry of new consumers or producers into the world mineral markets. Clearly, persons involved in these markets would like to have estimates of the impact of China's entry into the world economy. The simulation model provides for such a forecast by permitting the addition of new country groups (up to 3 new country groups per simulation). This type of simulation requires only the control card and one additional card for each new country group.

Finally, the simulation programs allows combinations of the preceding changes to be simulated simultaneously. In a particular simulation, the user can obtain forecasts assuming changes in the growth rates of the exogenous variables, exogenous changes in production, consumption, or price, and the entry of new producers and/or consumers.

TABLE 5-2
HISTORICAL GROWTH RATES FOR THE EXOGENOUS VARIABLES 1962-76

	Income	Capital	Interest Rate*	Rate of Growth of Money Supply*
North America	2.76	3.85	5.12	5.31
South America	2.93	6.93	N/A	N/A
Asia	4.50	12.19	N/A	N/A
Africa	1.83	7.45	N/A	N/A
Europe	3.30	3.93	3.13	9.09
Oceania	2.65	4.33	4.08	7.98
Centrally Planned	5.45	N/A	N/A	N/A
*Historical Average				
Copper Price	3.55			
Aluminum Price	-0.10			
Raw Steel Price	2.76			

TABLE 5-3
COPPER
ASSUMPTIONS
RATES OF CHANGE

	Income	Interest Rate	Money Growth Rate	Capital Acquisition
North America	2.76	5.12	5.31	3.85
South America	2.93	0.0	0.0	6.93
Asia	4.50	0.0	0.0	12.19
Africa	1.83	0.0	0.0	7.45
Europe	3.30	3.13	9.09	3.93
Oceania	2.65	4.08	7.98	4.38
Central Planned	5.45	0.0	0.0	0.0

Substitute Metal – Aluminum
Rate of Price Change -0.10

	North America		South America		Asia		Africa		Europe		Oceania		Centrally Planned	
Year	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand
1981	2486.8	2504.9	1365.0	463.8	469.4	1543.2	1744.2	109.1	185.2	3236.1	458.0	151.5	1825.8	2328.5
1982	2619.3	2587.6	1392.8	494.4	463.5	1586.8	1801.5	117.1	195.4	3352.0	488.9	159.9	1868.2	2474.0
1983	2776.5	2697.5	1415.8	519.8	463.9	1708.0	1854.8	124.5	206.8	3441.9	521.3	167.6	1913.7	2621.9
1984	2916.7	2810.3	1440.5	551.2	468.4	1807.1	1907.9	131.3	219.2	3550.0	553.8	176.2	1960.9	2777.5
1985	3066.1	2933.6	1462.7	580.6	477.7	1918.5	1961.8	137.1	232.5	3649.3	586.3	184.9	2011.6	2940.2
1986	3215.9	3054.6	1484.1	610.6	491.7	2031.6	2015.8	142.0	246.7	3747.9	618.7	193.6	2066.1	3110.4
1987	3371.4	3175.6	1505.2	641.4	510.4	2151.5	2070.4	146.2	261.7	3849.7	651.5	202.5	2124.2	3288.4
1988	3534.4	3299.4	1526.7	673.9	533.7	2277.3	2126.1	150.0	277.6	3959.1	685.2	211.7	2185.2	3475.5
1989	3706.5	3428.6	1548.1	707.7	561.7	2409.1	2183.1	153.4	294.3	4074.9	719.9	221.3	2249.1	3672.4
1990	3887.1	3563.0	1569.3	742.6	594.3	2546.8	2241.5	156.5	311.8	4194.9	755.8	231.1	2315.7	3879.9
1991	4075.6	3701.5	1590.0	778.4	631.7	2690.7	2301.0	159.2	330.2	4318.6	793.0	241.3	2385.0	4098.3

SECONDARY PRODUCTION

Year	North America	South America	Asia	Africa	Europe	Oceania	Centrally Planned
1981	481.1	57.8	125.5	0.0	481.5	36.1	N/A
1982	492.1	64.5	149.5	0.0	526.0	39.2	N/A
1983	509.0	70.9	156.3	0.0	564.2	41.9	N/A
1984	535.3	78.4	169.0	0.0	608.1	46.2	N/A
1985	566.4	86.2	179.9	0.0	652.0	50.5	N/A
1986	600.0	94.7	191.7	0.0	697.9	55.3	N/A
1987	634.5	103.3	203.6	0.0	743.4	60.1	N/A
1988	670.1	112.1	216.1	0.0	788.9	65.1	N/A
1989	707.4	121.2	229.1	0.0	835.2	70.1	N/A
1990	746.4	130.6	242.7	0.0	882.8	75.2	N/A
1991	787.0	140.4	256.8	0.0	932.1	80.4	N/A

WORLD

Year	Production	Scrap	Consumption	Price
1981	8534.4	1181.9	10337.0	96.220
1982	8829.6	1271.3	10771.8	106.861
1983	9152.7	1342.2	11281.2	115.326
1984	9467.4	1437.0	11803.5	127.610
1985	9798.8	1535.1	12344.1	140.713
1986	10138.9	1639.6	12890.6	153.858
1987	10494.7	1744.9	13455.4	166.378
1988	10868.9	1852.3	14046.9	178.872
1989	11262.7	1962.9	14667.4	191.809
1990	11675.5	2077.7	15314.7	205.288
1991	12106.5	2196.7	15988.0	219.168

- 6 -
SPECIFIC PROCEDURE

As has been stressed earlier, this computer simulation model has been designed so as to require a minimum of user-supplied commands. In this chapter, these commands will be described and illustrated. First, in section 6.1, the basic commands themselves are described. Then, in sections 6.2 through 6.6, the techniques by which specific forecasts can be obtained are discussed.

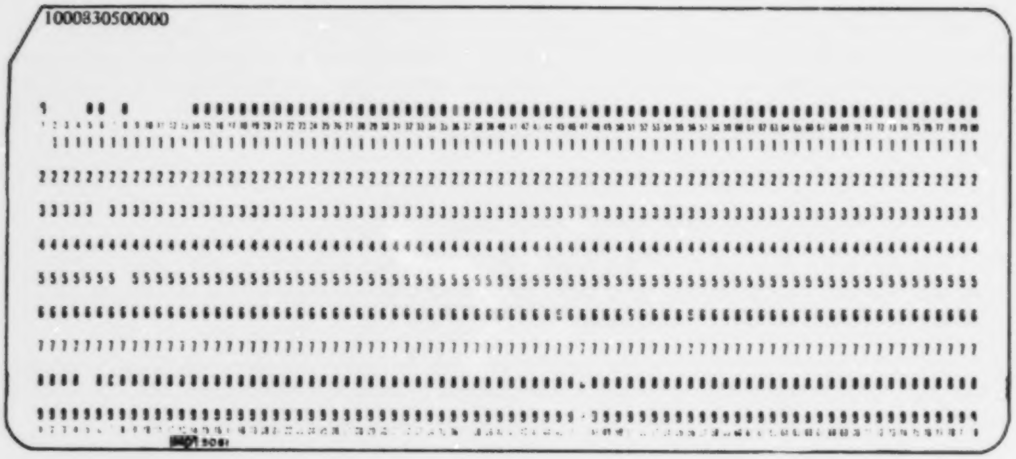
6.1 BASIC SIMULATION COMMANDS

In order to obtain a simulation, two types of commands are required — JCL commands and Simulation commands. Since JCL commands will be for the most part system specific, this discussion will concentrate on the simulation commands.

This simulation model uses card images; so, the descriptions will be in terms of an 80-column computer card. (Obviously, no changes need be made for a CRT system that interprets card images.) The simulation commands come in five types. Following is a description of each of these.

Card #1: The Control Card
This card (or statement) is required for any simulation. It contains information on (1) the mineral commodity to be simulated, (2) the type of output desired, (3) the plots desired, (4) the beginning year for the forecast (default 1981), (5) the number of years to be forecast, (6) the number of growth rates of the exogenous variables that are to be altered, (7) the number of exogenous changes in production, consumption, or price and (8) the number of new suppliers and/or demanders. Numbers are entered on this card with the format 2I1, 5I2, I1 in the following manner:

Column # -	IMINRL - A one-digit number that selects the mineral to be simulated 1 - Copper 2- Aluminum 3 - Nickel 4 - Zinc 5 - Modified Nickel Model (See Chapter 4)
Column #2 -	IPRTCT - A one-digit number that selects the type of output desired 0 - CRT output 1 - Line printer output 2 - Both outputs
Columns #3 & 4 -	IPLOT - A two digit number specifying the number of plots required. (See card #2 below.)
Columns #5 & 6 -	IFSTYR - The last two digits of the year in which forecasts are to be begun.
Columns #7 & 8 -	ISIMYR - The total number of years to be forecast - a two digit number.
Columns #9 & 10 -	IGROW - a two-digit number that specifies the number of growth rates of the exogenous variables that are to be altered. (See card #3 below)
Columns #11 & 12 -	ISHIFT - A two-digit number specifying the number of exogenous (non-market) changes in primary production, secondary production, consumption, or price. (See card #4 below.)
Column #13 -	IEXTRA - A one-digit number denoting the number of *new* suppliers and/or demanders to be simulated. (See card #5 below.)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5081

Illustration 1

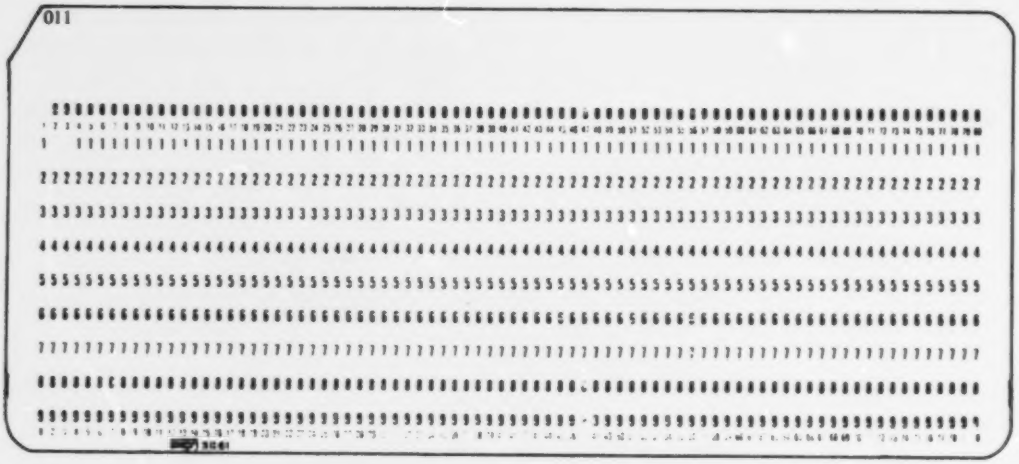


Illustration 2

For example, if one wished to simulate the base case for copper for the period 1983 through 1987 using a CRT format without any plots, this card would be as shown in Illustration 1.

Card Type #2: Plots

For every plot desired, one of this type of card is required. Note also that the number of this type of card must be equal to the number specified as IPLOT (columns 3-4) on card #1. However, if IPLOT is specified as 00, this card should be omitted. The commands on this card are entered in the format I1, I2 as follows:

Column #1 - IVAR - A one-digit number denoting the variable to be plotted

0 - All variables
1 - Primary production
2 - Secondary production
3 - Consumption
4 - Price

Column #2 - ICTPLT - A two-digit number indicating the country group to be plotted

00 - World
01 - North America
02 - South America
03 - Asia
04 - Africa
05 - Europe
06 - Oceania
07 - Centrally Planned
08 }
09 } Any new sources of supply or demand (See card type #5)
10 }
11 - All country groups and the world levels

For example, if one wished to plot all variables for all of the country groups and the world, card #2 would be as shown in Illustration 2.

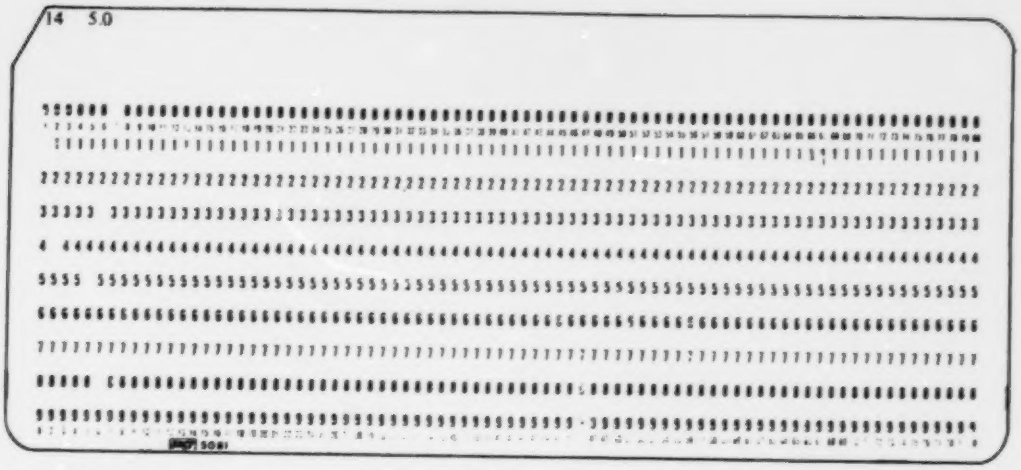

14 5.0
IBM 5081

Illustration 3

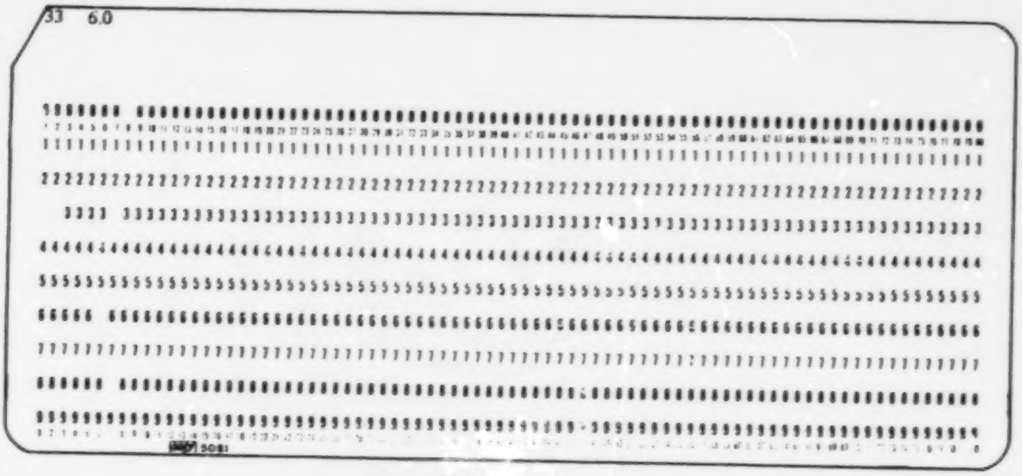

33 6.0
IBM 5081

Illustration 4

Card Type #3: Changes in the growth rates of the exogenous variables

If one wishes to alter the growth rates of the exogenous variables — income, the interest rate, capital accumulation, money supply, and the price of the related commodity — this type of card is required. For every change desired, one of this type of card is necessary; the number of this type of card must be equal to the number specified as IGROW (Columns 9-10) on card #1. If IGROW was specified to be 00, this card should be omitted. The commands on this card are entered in the format 2I1, F14.6 as follows:

Column #1 -	ICNT - A one-digit number that denotes the country group in which the change is to be made. 0 - World 1 - North America 2 - South America 3 - Asia 4 - Africa 5 - Europe 6 - Oceania 7 - Centrally Planned Economies
Column #2 -	IGRT - A one-digit number indicating the variable for which the growth rate is to be altered. 1 - Income 2 - Interest Rate 3 - Capital Accumulation 4 - Money Supply 5 - Price of the Related Commodity
Columns #3 through 16 -	USRGRT - The altered growth rate This number - with a decimal point - indicates the alternative growth rate of the exogenous variable specified in column #2. Note that this value should be entered in percentage terms — i.e., a 10% growth rate should be entered at 10.0, not 0.10.

If the growth rate of the monetary base in North America is assumed to be 5% annually, the required card is shown in Illustration 3. Alternatively, if the rate of growth of capital accumulation in Asia is assumed to be 6%, the necessary card is presented in Illustration 4.

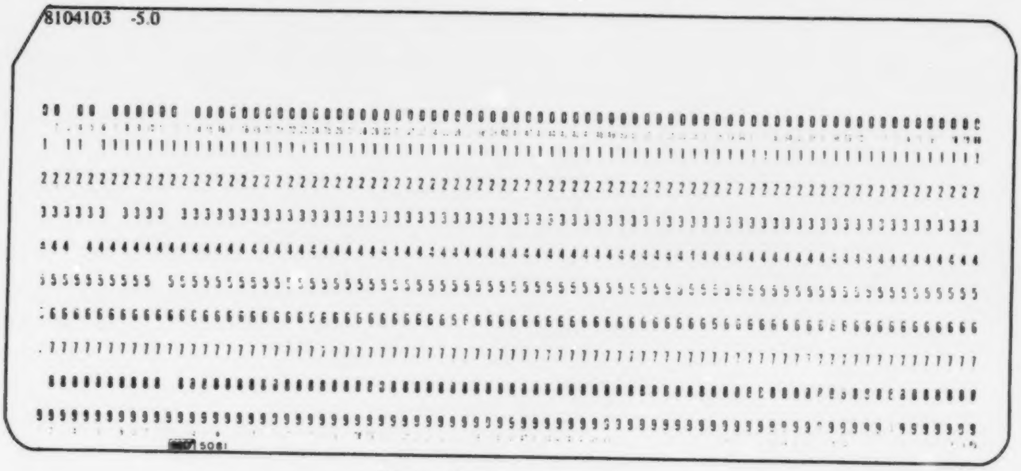
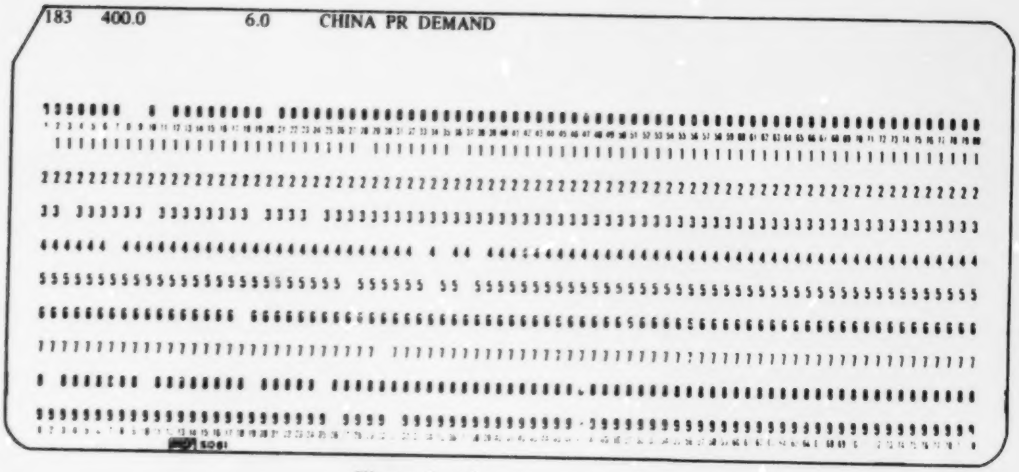


Illustration 5

Card Type #4: Exogenous (e.g., Politically Determined) changes in the endogenous variables
If the user desires to simulate the impact of exogenous changes in one or more of the endogenous variables, this type of card is required. One of these cards is required for each exogenous change; so, the number of these cards will equal the number specified as ISHIFT (Columns 11-12) of card #1. Note, however, that, if ISHIFT is equal to 00, this card should be omitted. Commands are entered on this card in the format 2I2, I1, I2, F10.4 as follows:

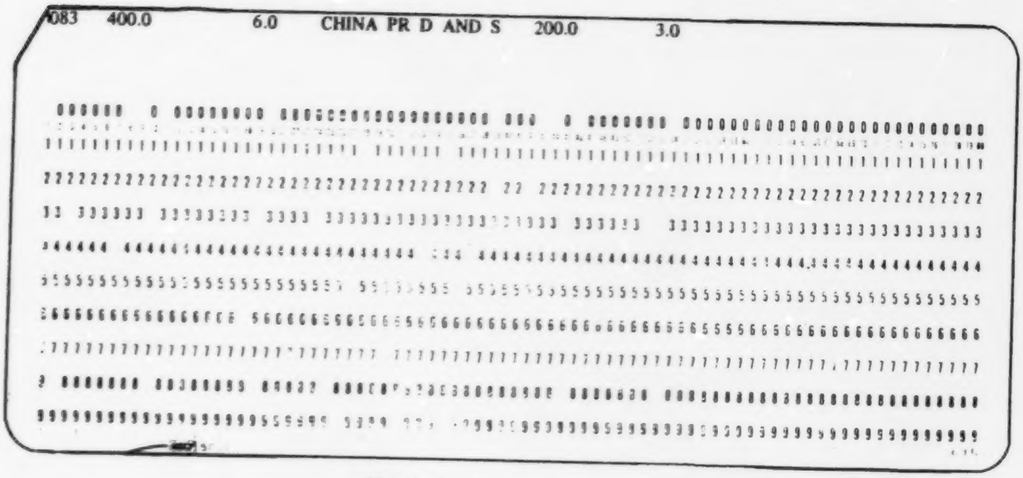
Columns 1 & 2 -	IYRSFT - The last two digits of the year in which the exogenous change begins
Columns 3 & 4 -	ICOUNTRY - A two digit number denoting the country group in which the exogenous change occurs 00 - World 01 - North America 02 - South America 03 - Asia 04 - Africa 05 - Europe 06 - Oceania 07 - Centrally Planned 08 09 } Any new sources of supply or demand (See card #5) 10
Column #5 -	IVAR - A one-digit number denoting the variable to be altered 1 - Primary Production 2 - Secondary Production 3 - Consumption 4 - Price
Columns #6 & 7 -	ILEN - A two-digit number specifying the number of years that the exogenous shift will continue
Columns #8-17 -	SHIFT - The magnitude of the exogenous shift expressed as a percentage. For instance, a 10% increase would be shown as 10.0, while a 5% decrease would be indicated by -5.0.

If, for example, one wished to simulate the impact of a 5% reduction in primary production from Africa for the period 1981-1983, card type #4 would be as shown in Illustration 5.



183 400.0 6.0 CHINA PR DEMAND

Illustration 6



083 400.0 6.0 CHINA PR D AND S 200.0 3.0

Illustration 7

Card Type #5: New sources of supply and/or demand

If the user wishes to simulate the entry of new sources of supply or demand this card is required. One of this type of card is required for every new source; so, the number of these cards must be equal to the number specified in IEXTRA (column #13) on card #1. Instructions are entered on this card in the format I1, I2, 2F10.4, A16, 2F10.4 as follows:

Column #1 -	ITYPE - A one-digit number that indicates whether the new source is a producer, a consumer, or both. 0 - both production and consumption 1 - consumption only 2 - production only
Columns #2 & 3 -	IYRST1 - The last two digits of the year in which the new production and/or consumption is assumed to begin.
Columns #4-13 -	AMT1 - The initial consumption or production level. If ITYPE was 0 or 1, enter the initial consumption level. If ITYPE was 2, enter the initial production level in these columns. It is necessary to specify the decimal point in this number.
Columns #14-23 -	GRT1 - The annual growth rate of the variable denoted by AMT1, specified as a percentage — e.g., a 5% annual growth rate would be entered as 5.0.
Columns #24-39 -	NAM - The name assigned to the new source of consumption and production.
Columns #40-49 -	AMT2 - These columns are used only if ITYPE is equal to 2. If ITYPE is equal to 2, enter the initial production in these columns, otherwise they are left blank.
Columns #50-59 -	GRT2 - The annual growth rate in the variable denoted by AMT2, expressed as a percentage. If columns 40-49 were left blank, these columns should also be blank.

For example, suppose one wished to simulate the entry of the People's Republic of China into the world mineral market. Suppose further that it is assumed that Chinese consumption will begin at a level of 400 thousand metric tons in 1983 and that this consumption is expected to increase at an annual rate of 6%. Using the name "CHINA PR DEMAND", the necessary card is shown in Illustration 6. If, in addition, one assumed that production will begin at 200 thousand metric tons (in 1983) and will grow at an annual rate of 3%, card #5 would be as shown in Illustration 7.

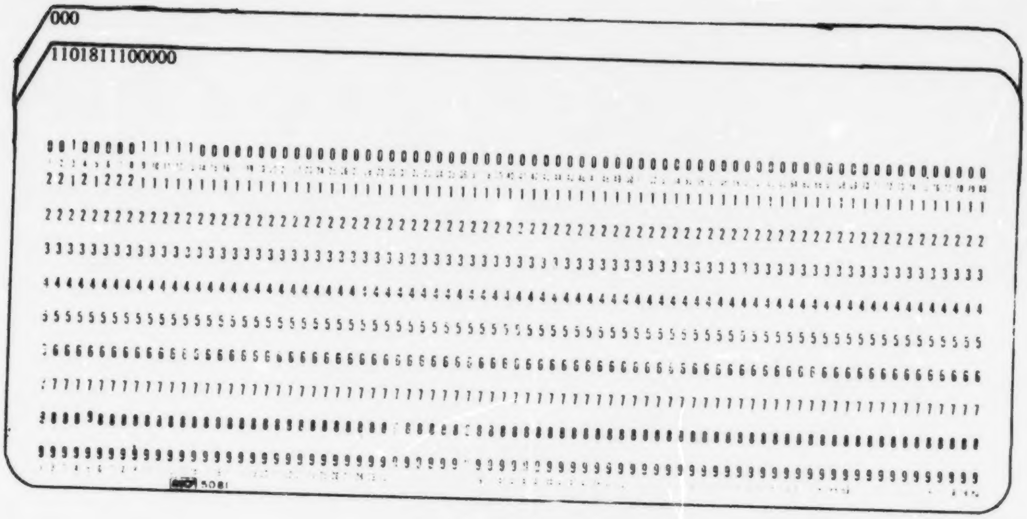

000
1101811100000

Illustration 8

6.2 BASE SIMULATIONS

In order to obtain base simulations — i.e., one in which all of the exogenous variables follow historical trend — only card #1 is required. Furthermore, on this card, only IMINRL, IPRTCT, IPLOT, IFSTYR, and ISIMYR must be specified. However, if plots are desired, card or cards of type #2 will also be necessary.

For example, if one desires a base simulation for copper for the period 1981-1991 and desires the output to be in the line printer format with plots for the world values of primary production, secondary production, consumption, and price, the necessary simulation command cards are presented in Illustration 8. The output of this simulation is shown in Illustration 9. Note that the program lists the simulation cards in order to aid in checking for errors.

Alternatively, suppose one desires a base simulation for aluminum for the period 1985-1991. Suppose further that the user requires a CRT format with no plots. In this case, only card #1 is needed. The appropriate card is presented in Illustration 10 and the resulting output is shown in Illustration 11.

Illustration 9

Note: Illustration 9 is presented on pages 76 through 82. Each page represents one page of computer output in its original format. For clarity in this publication, the type has been reset and the graphs have been redrawn with data points connected.

```
                                   LIST OF DATA CARDS
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       0 0
```

COPPER
ASSUMPTIONS
RATES OF CHANGE

	Income	Interest Rate	Money Growth Rate	Capital Acquisition
North America	2.76	5.12	5.31	3.85
South America	2.93	0.0	0.0	6.93
Asia	4.50	0.0	0.0	12.19
Africa	1.83	0.0	0.0	7.45
Europe	3.30	3.13	9.09	3.93
Oceania	2.65	4.08	7.98	4.38
Central Planned	5.45	0.0	0.0	0.0

Substitute Metal – Aluminum
Rate of Price Change -0.10

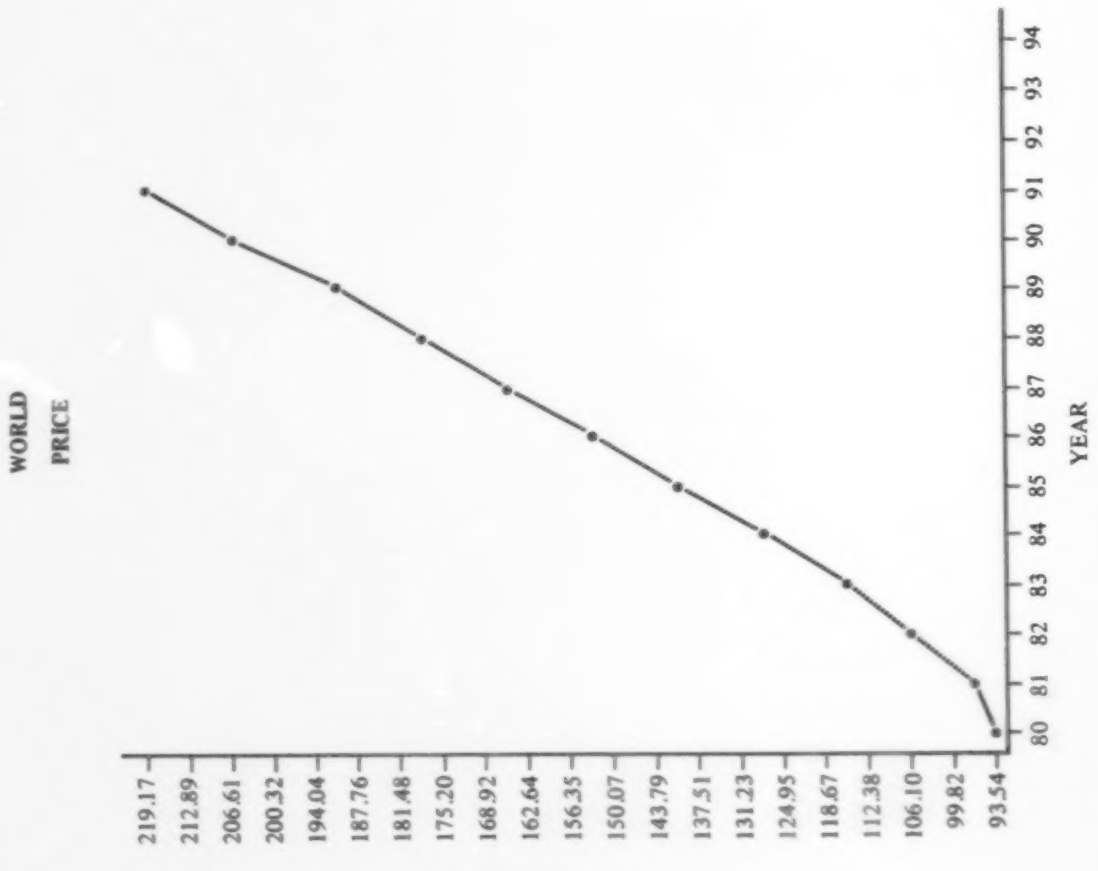
	North America		South America		Asia		Africa		Europe		Oceania		Centrally Planned	
Year	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand
1981	2486.8	2504.9	1365.0	463.8	469.4	1543.2	1744.2	109.1	185.2	3236.1	458.0	151.5	1825.8	2328.5
1982	2619.3	2587.6	1392.8	494.4	463.5	1586.8	1801.5	117.1	195.4	3352.0	488.9	159.9	1868.2	2474.0
1983	2776.5	2697.5	1415.8	519.8	463.9	1708.0	1854.8	124.5	206.8	3441.9	521.3	167.6	1913.7	2621.9
1984	2916.7	2810.3	1440.5	551.2	468.4	1807.1	1907.9	131.3	219.2	3550.0	553.8	176.2	1960.9	2777.5
1985	3066.1	2933.6	1462.7	580.6	477.7	1918.5	1961.8	137.1	232.5	3649.3	586.3	184.9	2011.6	2940.2
1986	3215.9	3054.6	1484.1	610.6	491.7	2031.6	2015.8	142.0	246.7	3747.9	618.7	193.6	2066.1	3110.4
1987	3371.4	3175.6	1505.2	641.4	510.4	2151.5	2070.4	146.2	261.7	3849.7	651.5	202.5	2124.2	3288.4
1988	3534.4	3299.4	1526.7	673.9	533.7	2277.3	2126.1	150.0	277.6	3959.1	685.2	211.7	2185.2	3475.5
1989	3706.5	3428.6	1548.1	707.7	561.7	2409.1	2183.1	153.4	294.3	4074.9	719.9	221.3	2249.1	3672.4
1990	3887.1	3563.0	1569.3	742.6	594.3	2546.8	2241.5	156.5	311.8	4194.9	755.8	231.1	2315.7	3879.9
1991	4075.6	3701.5	1590.0	778.4	631.7	2690.7	2301.0	159.2	330.2	4318.6	793.0	241.3	2385.0	4098.3

SECONDARY PRODUCTION

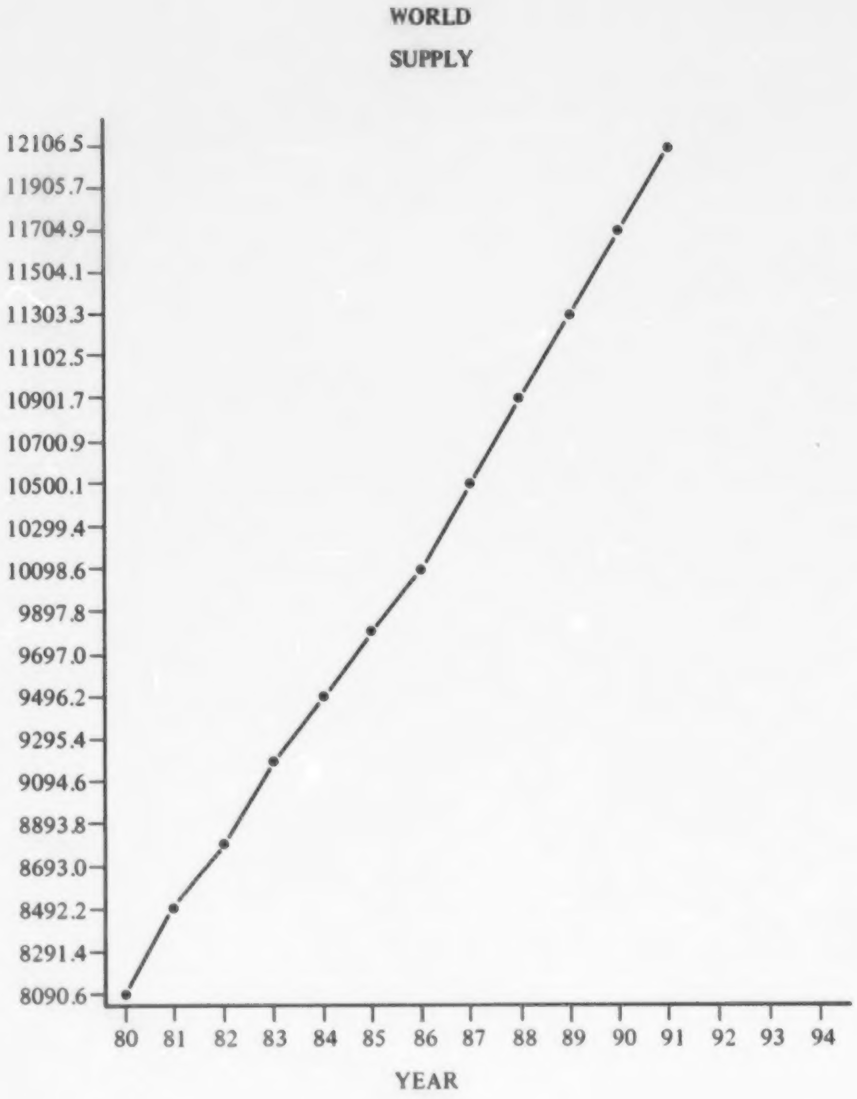
Year	North America	South America	Asia	Africa	Europe	Oceania	Centrally Planned
1981	481.1	57.8	125.5	0.0	481.5	36.1	N/A
1982	492.1	64.5	149.5	0.0	526.0	39.2	N/A
1983	509.0	70.9	156.3	0.0	564.2	41.9	N/A
1984	535.3	78.4	169.0	0.0	608.1	46.2	N/A
1985	566.4	86.2	179.9	0.0	652.0	50.5	N/A
1986	600.0	94.7	191.7	0.0	697.9	55.3	N/A
1987	634.5	103.3	203.6	0.0	743.4	60.1	N/A
1988	670.1	112.1	216.1	0.0	788.9	65.1	N/A
1989	707.4	121.2	229.1	0.0	835.2	70.1	N/A
1990	746.4	130.6	242.7	0.0	882.8	75.2	N/A
1991	787.0	140.4	256.8	0.0	932.1	80.4	N/A

WORLD

Year	Production	Scrap	Consumption	Price
1981	8534.4	1181.9	10337.0	96.220
1982	8829.6	1271.3	10771.8	106.861
1983	9152.7	1342.2	11281.2	115.326
1984	9467.4	1437.0	11803.5	127.610
1985	9798.8	1535.1	12344.1	140.713
1986	10138.9	1639.6	12890.6	153.858
1987	10494.7	1744.9	13455.4	166.378
1988	10868.9	1852.3	14046.9	178.872
1989	11262.7	1962.9	14667.4	191.809
1990	11675.5	2077.7	15314.7	205.288
1991	12106.5	2196.7	15988.0	219.168


WORLD
PRICE
219.17
212.89
206.61
200.32
194.04
187.76
181.48
175.20
168.92
162.64
156.35
150.07
143.79
137.51
131.23
124.95
118.67
112.38
106.10
99.82
93.54
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
YEAR

COPPER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SUPPLY
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11905.7
11704.9
11504.1
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10700.9
10500.1
10299.4
10098.6
9897.8
9697.0
9496.2
9295.4
9094.6
8893.8
8693.0
8492.2
8291.4
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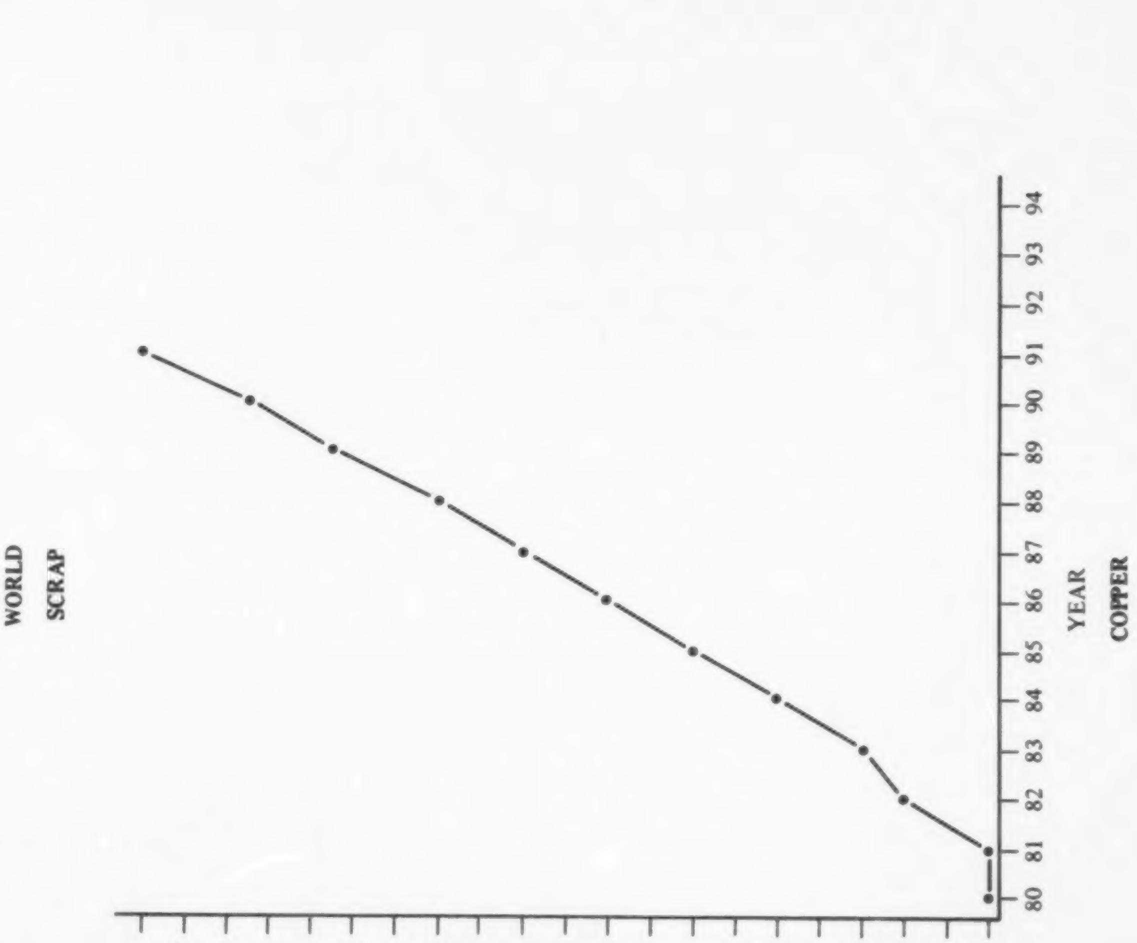
92
93
94
YEAR

COPPER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SCRAP
COPPER
YEAR
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2145.9
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2044.4
1993.7
1943.0
1892.2
1841.5
1790.8
1740.0
1689.3
1638.6
1587.8
1537.1
1486.4
1435.6
1384.9
1334.1
1283.4
1232.7
1181.9
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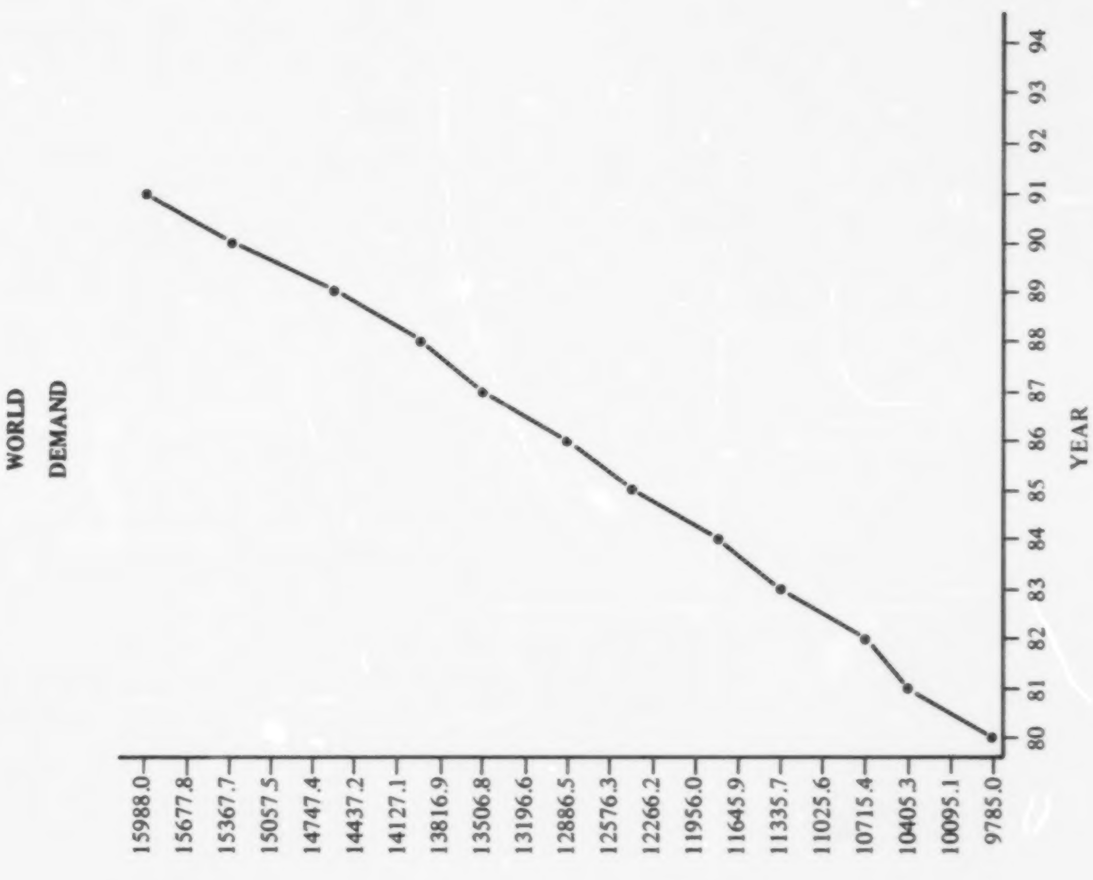
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DEMAND
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15057.5
14747.4
14437.2
14127.1
13816.9
13506.8
13196.6
12886.5
12576.3
12266.2
11956.0
11645.9
11335.7
11025.6
10715.4
10405.3
10095.1
9785.0
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83
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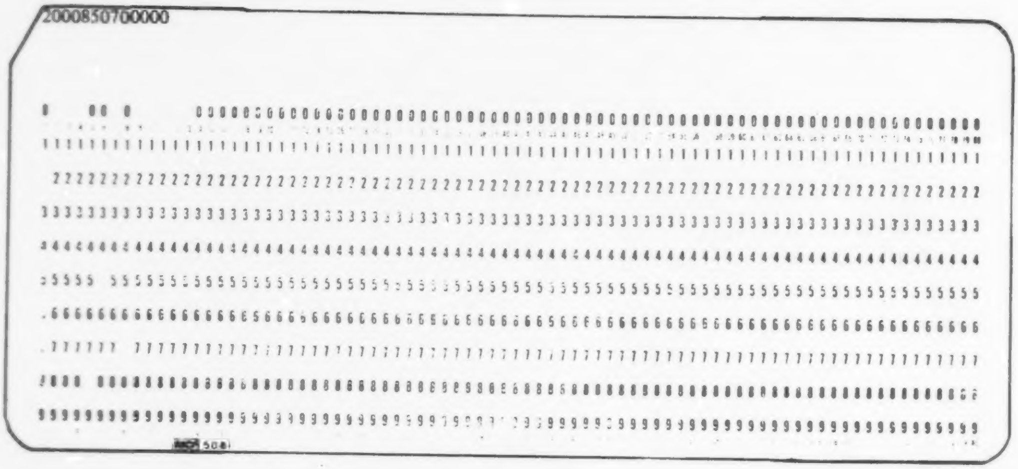
85
86
87
88
89
90
91
92
93
94
YEAR

COPPER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508

Illustration 10

Illustration 11

Note: Illustration 11 is presented on pages 84 through 86. Each page represents one page of computer output in its original format. For clarity in this publication, the type has been reset.

```
                 LIST OF DATA CARDS

RULE     1234567810_234567820_234567830_234567840_
         20 085 7 0 00
```

ALUMINUM
ASSUMPTIONS
RATES OF CHANGE

	Income	Interest Rate	Money Growth Rate	Capital Acquisition
North America	2.76	5.12	5.31	3.85
South America	2.93	0.0	0.0	6.93
Asia	4.50	0.0	0.0	12.19
Africa	1.83	0.0	0.0	7.45
Europe	3.30	3.13	9.09	3.93
Oceania	2.65	4.08	7.98	4.38
Central Planned	5.45	0.0	0.0	0.0

Substitute Metal – Copper
Rate of Price Change 3.55

NORTH AMERICA

Year	Supply	Scrap	Demand	Price
1985	6627.8	1971.4	7734.4	54.320
1986	6835.0	2071.9	8122.4	55.584
1987	7049.9	2178.2	8521.7	56.920
1988	7270.5	2289.5	8932.0	58.335
1989	7495.9	2405.5	9353.5	59.871
1990	7725.4	2526.0	9786.7	61.573
1991	7958.3	2650.7	10231.8	63.474

SOUTH AMERICA

Year	Supply	Scrap	Demand	Price
1985	2352.2	88.7	689.2	54.320
1986	2607.7	92.9	721.3	55.584
1987	2866.1	97.1	754.1	56.920
1988	3132.1	101.4	787.5	58.335
1989	3409.3	105.7	821.5	59.871
1990	3701.3	110.0	856.1	61.573
1991	4010.9	114.4	891.2	63.474

ASIA

Year	Supply	Scrap	Demand	Price
1985	2423.0	1036.3	3552.1	54.320
1986	2596.9	1099.4	3773.5	55.584
1987	2781.7	1166.0	4004.9	56.920
1988	2977.1	1236.0	4246.6	58.335
1989	3183.1	1309.6	4499.3	59.871
1990	3399.9	1386.6	4763.3	61.573
1991	3627.8	1467.3	5039.2	63.474

AFRICA

Year	Supply	Scrap	Demand	Price
1985	614.0	18.8	219.7	54.320
1986	664.1	19.5	230.7	55.584
1987	716.6	20.2	242.1	56.920
1988	771.5	21.0	253.7	58.335
1989	828.9	21.9	265.5	59.871
1990	888.8	22.9	277.7	61.573
1991	951.5	23.9	290.2	63.474

EUROPE

Year	Supply	Scrap	Demand	Price
1985	5917.3	1547.9	4809.3	54.320
1986	6337.5	1622.4	5044.5	55.584
1987	6781.2	1700.9	5289.5	56.920
1988	7250.4	1783.1	5544.2	58.335
1989	7746.5	1868.9	5808.5	59.871
1990	8270.9	1958.2	6082.7	61.573
1991	8825.1	2051.2	6367.2	63.474

OCEANIA

Year	Supply	Scrap	Demand	Price
1985	757.4	50.6	280.4	54.320
1986	828.5	53.1	294.1	55.584
1987	904.3	55.9	308.1	56.920
1988	984.2	58.7	322.6	58.335
1989	1068.2	61.6	337.4	59.871
1990	1156.1	64.6	352.6	61.573
1991	1248.0	67.6	368.2	63.474

CENTRAL PLANNED

Year	Supply	Scrap	Demand	Price
1985	4647.0	0.0	4426.0	54.320
1986	4897.3	0.0	4710.5	55.584
1987	5156.5	0.0	5008.7	56.920
1988	5425.1	0.0	5322.0	58.335
1989	5703.9	0.0	5651.8	59.871
1990	5993.8	0.0	5999.3	61.573
1991	6295.4	0.0	6365.6	63.474

WORLD

Year	Supply	Scrap	Demand	Price
1985	23338.8	4713.7	21711.1	54.320
1986	24767.0	4959.2	22897.1	55.584
1987	26256.3	5218.2	24129.0	56.920
1988	27810.9	5489.7	25408.5	58.335
1989	29435.8	5773.2	26737.5	59.871
1990	31136.2	6068.3	28118.3	61.573
1991	32917.1	6375.2	29553.4	63.474

6.3 CHANGES IN THE GROWTH RATES OF THE EXOGENOUS VARIABLES

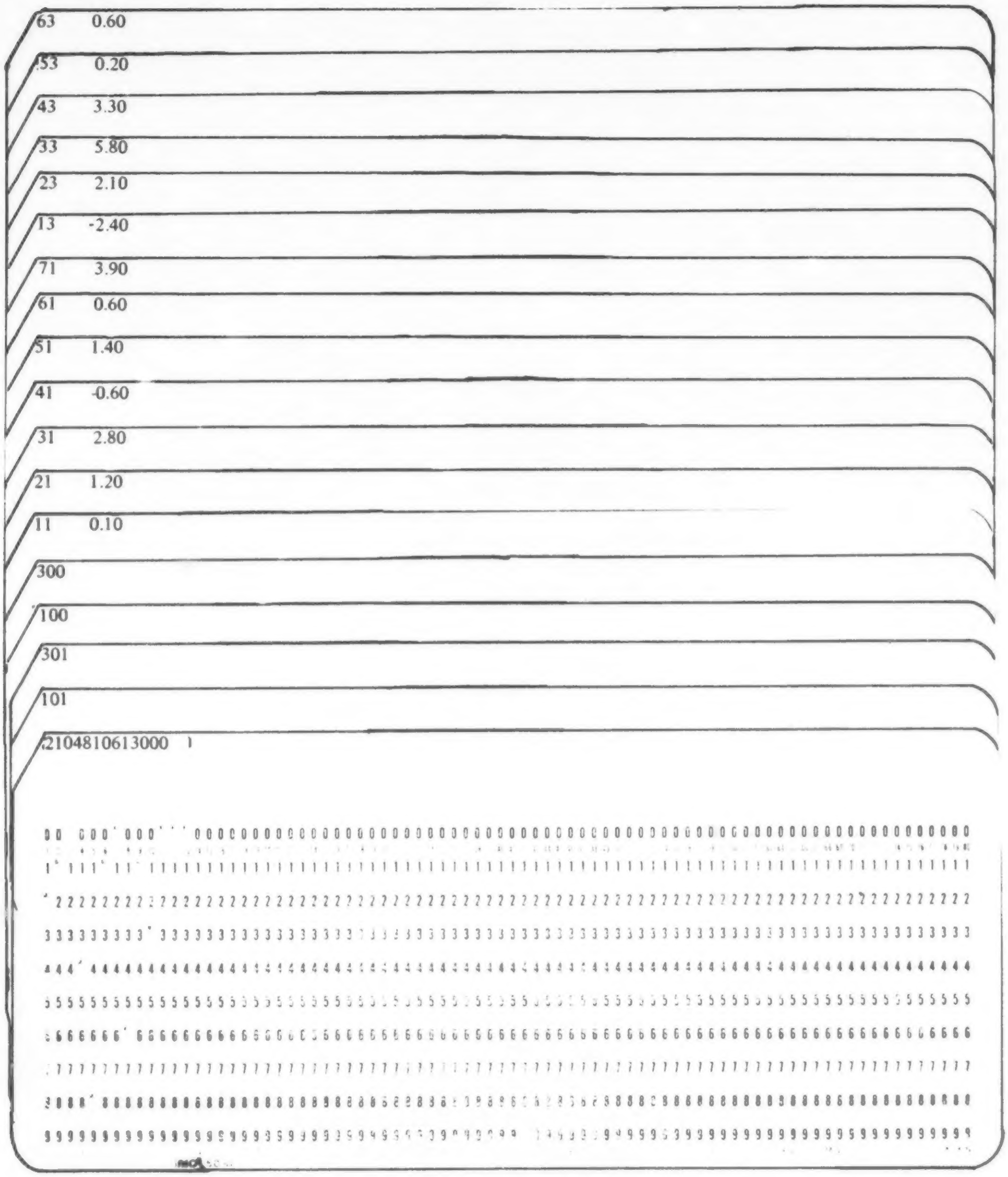
For simulations that incorporate the effect of changes in the exogenous variables — i.e., income, the interest rate, the rate of money growth, capital accumulation, and the price of the related commodity — cards (or statements) of the type #3 are required, in addition to card #1 (and cards of type #2, if plots are desired). On card #1, the number of exogenous variables that are to be changed is specified as IGROW (columns 9-10). For *each* of the exogenous variables a card of type #2 is required.

To illustrate this type of simulation, suppose one wishes to simulate the Aluminum market assuming that the growth rates for income and capital accumulation will be one standard deviation below the historical trends for the period 1962-1976. Thus, the growth rates hypothesized would be

	Income	Capital Accumulation
North America	0.10%	-2.40%
South America	1.20%	2.10%
Asia	2.80%	5.80%
Africa	-0.60%	3.30%
Europe	1.40%	0.20%
Oceania	0.60%	0.60%
Centrally Planned	3.90%	N/A

Suppose further that the simulation is desired for the period 1981-1986 and that a line printer format is desired, with plots for the simulated values of primary production and consumption for North America and the World. The necessary simulation cards are displayed in Illustration 12. Note that the second through the fifth cards specify the plots. The sixth through twelfth cards denote the altered rates of growth of income and the thirteenth through eighteenth cards indicate the revised growth rates for capital accumulation. The resulting simulation is displayed in Illustration 13.

In order to introduce changes in interest rates or the rates of growth of the money supplies, similar procedures are employed. Note, however, that both of these variables are always expressed as percentages. For example, if one wishes to change the interest rate in North America to 10%, USRGT (columns 3-16 on card type #2) will be 10.0.



63 0.60

53 0.20

43 3.30

33 5.80

23 2.10

13 -2.40

71 3.90

61 0.60

51 1.40

41 -0.60

31 2.80

21 1.20

11 0.10

300

100

301

101

2104810613000

Illustration 12

Illustration 13

Note: Illustration 13 is presented on pages 89 through 95. Each page represents one page of computer output in its original format. For clarity in this publication, the type has been reset and the graphs have been redrawn with data points connected.

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       3 0
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       21        1.200000
       31        2.800000
       41       -0.600000
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       61        0.600000
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       13       -2.400000
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ALUMINUM
ASSUMPTIONS
RATES OF CHANGE

	Income	Interest Rate	Money Growth Rate	Capital Acquisition
North America	0.10	5.12	5.31	-2.40
South America	1.20	0.0	0.0	2.10
Asia	2.80	0.0	0.0	5.80
Africa	-0.60	0.0	0.0	3.30
Europe	1.40	3.13	9.09	0.20
Oceania	0.60	4.08	7.98	0.60
Central Planned	3.90	0.0	0.0	0.0

Substitute Metal – Copper
Rate of Price Change 3.55

The Following Growth Rates Have Been Altered.

Country Group	Variable	Rate
North America	Income	0.1
South America	Income	1.2
Asia	Income	2.8
Africa	Income	-0.6
Europe	Income	1.4
Oceania	Income	0.6
Central Planned	Income	3.9
North America	Capital	-2.4
South America	Capital	2.1
Asia	Capital	5.8
Africa	Capital	3.3
Europe	Capital	0.2
Oceania	Capital	0.6

Year	North America		South America		Asia		Africa		Europe		Oceania		Centrally Planned	
	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand
1981	5547.8	5664.7	1220.8	534.4	1799.5	2393.8	415.2	166.3	4260.2	3749.1	495.4	213.1	3682.0	3318.1
1982	5286.2	5665.3	1543.3	538.1	1922.9	2494.8	448.3	165.2	4522.4	3840.3	537.0	216.3	3758.0	3531.4
1983	5215.8	5671.1	1835.2	545.5	2048.1	2604.9	480.8	163.4	4762.4	3930.6	581.3	218.9	3918.7	3729.7
1984	5135.6	5682.2	2108.9	546.8	2180.3	2719.1	514.2	162.5	5007.6	4032.9	631.9	221.8	4086.7	3929.6
1985	5073.4	5696.5	2373.3	548.6	2322.4	2836.6	549.3	161.8	5259.8	4142.2	688.4	224.6	4255.7	4131.4
1986	5016.2	5712.3	2635.3	550.3	2474.6	2957.5	586.3	161.1	5522.5	4257.3	750.2	227.5	4430.8	4337.6

SECONDARY PRODUCTION

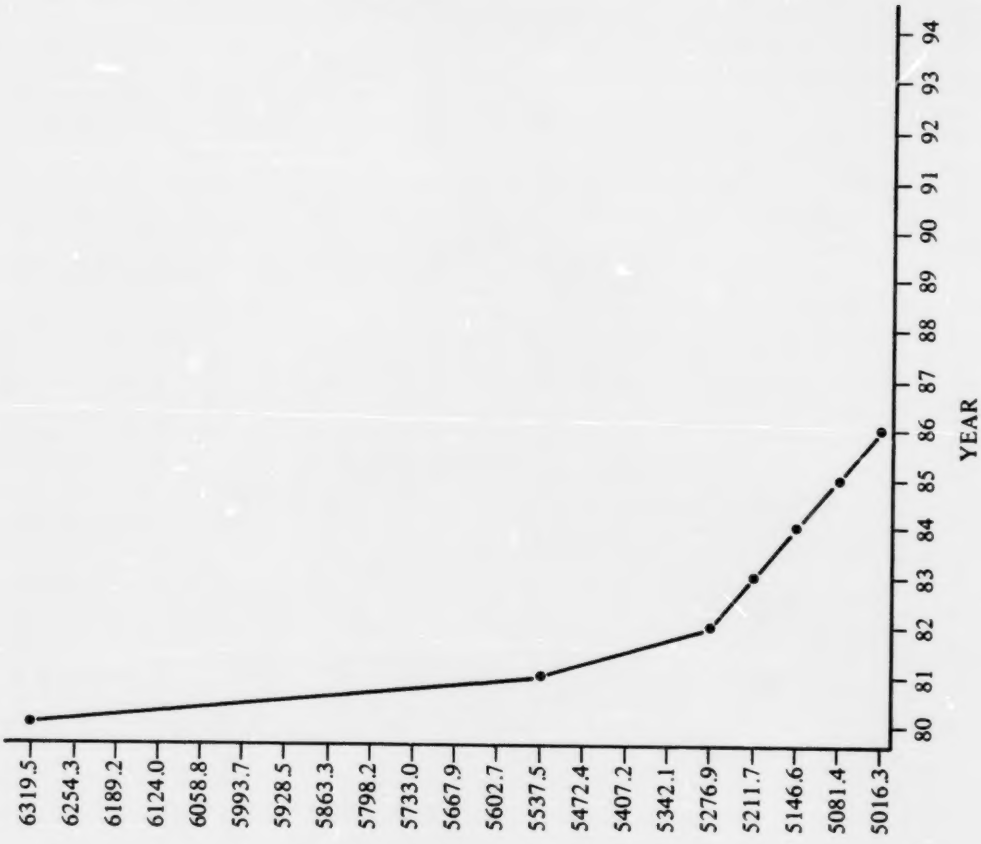
Year	North America	South America	Asia	Africa	Europe	Oceania	Centrally Planned
1981	1593.0	72.2	708.0	16.6	1236.7	40.2	N/A
1982	1607.0	64.5	733.9	16.9	1267.0	42.8	N/A
1983	1621.9	66.4	763.0	17.1	1299.2	42.6	N/A
1984	1637.2	66.8	794.7	17.5	1336.8	42.7	N/A
1985	1653.3	66.3	828.7	17.9	1378.5	43.2	N/A
1986	1670.0	65.7	864.7	18.3	1423.8	43.7	N/A

WORLD

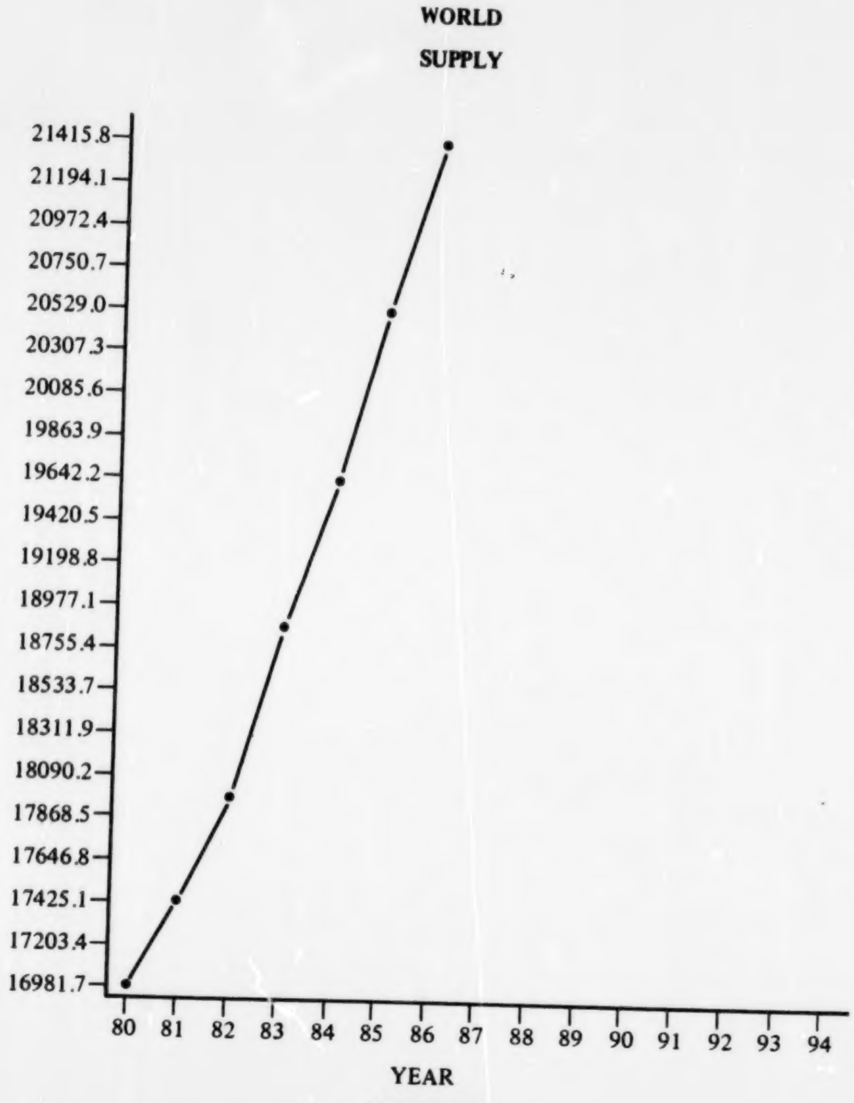
Year	Production	Scrap	Consumption	Price
1981	17420.9	3666.8	16039.4	57.958
1982	18018.0	3732.2	16451.3	60.619
1983	18842.2	3810.1	16864.0	64.905
1984	19665.2	3895.7	17294.8	70.110
1985	20522.4	3987.8	17741.7	75.717
1986	21415.8	4086.3	18203.6	81.486

NORTH AMERICA

SUPPLY



ALUMINUM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SUPPLY
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20750.7
20529.0
20307.3
20085.6
19863.9
19642.2
19420.5
19198.8
18977.1
18755.4
18533.7
18311.9
18090.2
17868.5
17646.8
17425.1
17203.4
16981.7
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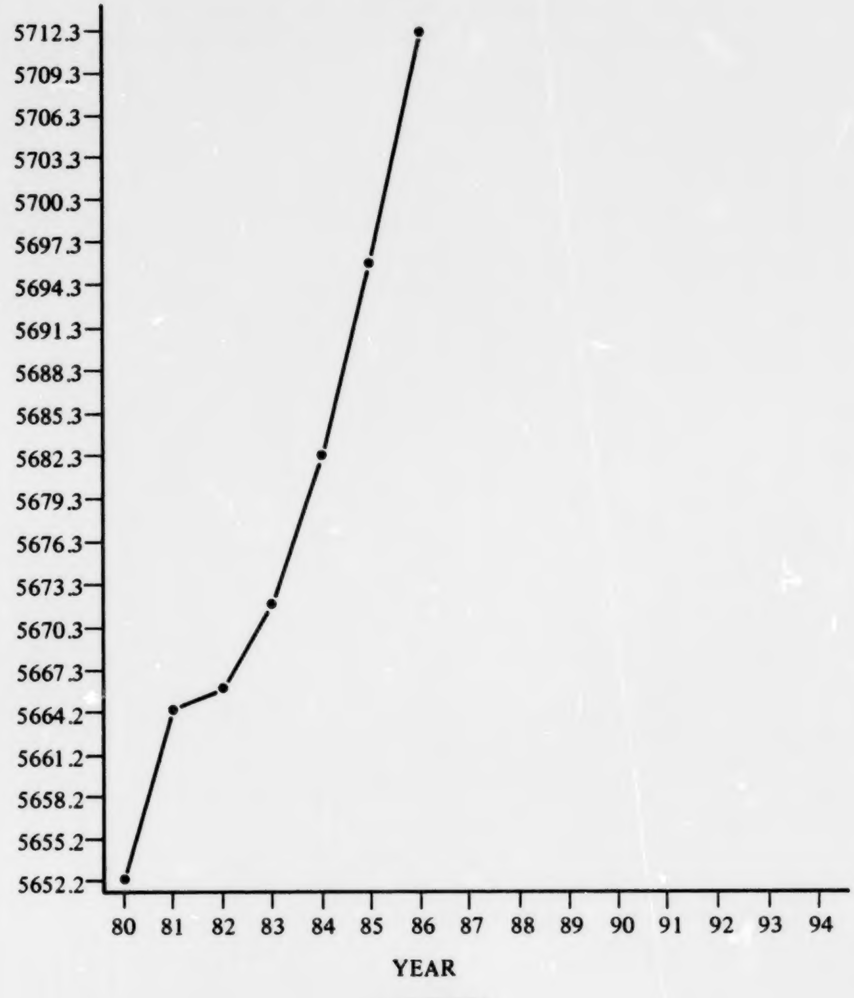
93
94
YEAR

ALUMINUM

NORTH AMERICA
DEMAND



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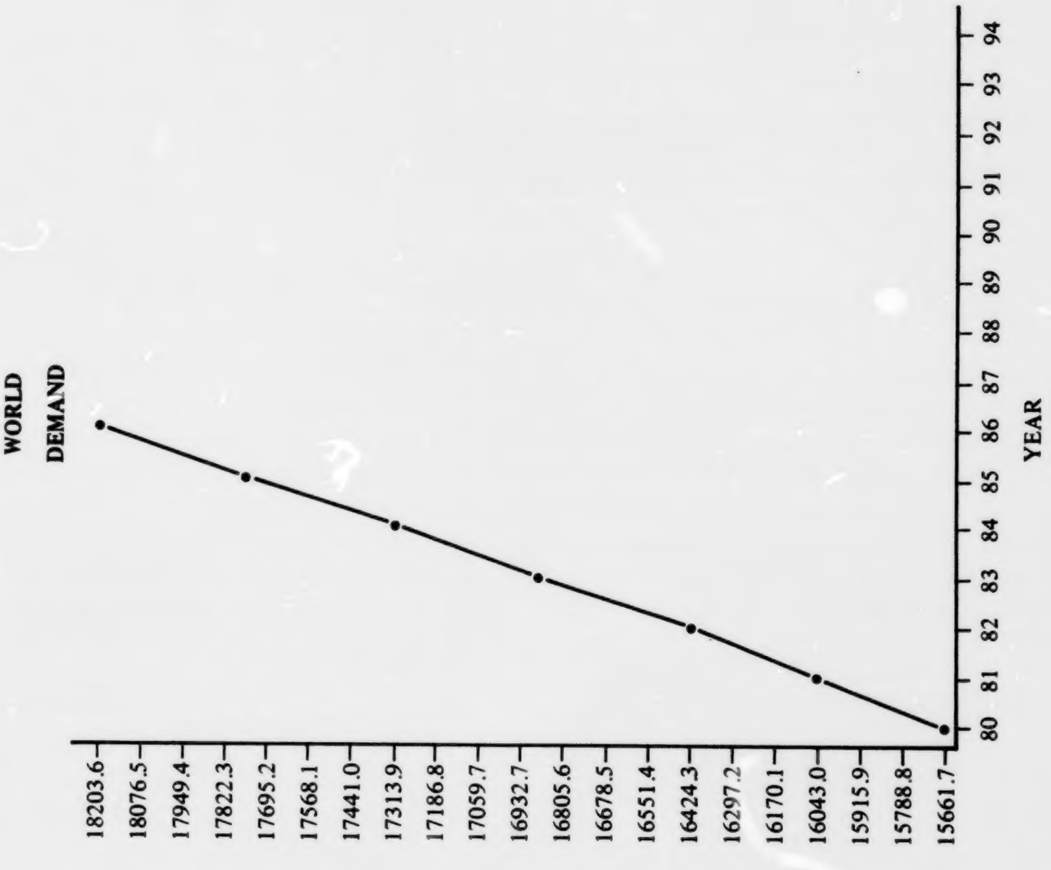
WORLD
DEMAND
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18076.5
17949.4
17822.3
17695.2
17568.1
17441.0
17313.9
17186.8
17059.7
16932.7
16805.6
16678.5
16551.4
16424.3
16297.2
16170.1
16043.0
15915.9
15788.8
15661.7
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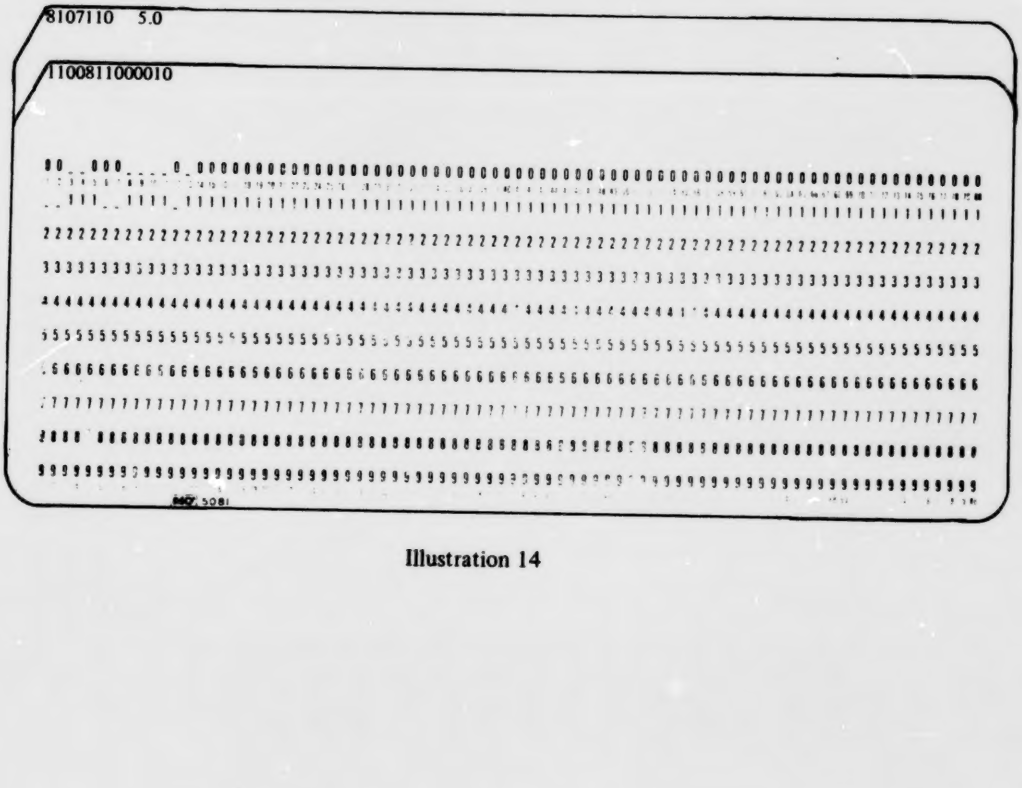
YEAR

ALUMINUM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1100811000010
5081

Illustration 14

6.4 EXOGENOUS CHANGES IN PRODUCTION, CONSUMPTION, AND/OR PRICE

The objective of this type of simulation is to examine the impact of non-market changes in the variables under consideration — production, consumption, and price. Such changes could be the result of political actions or of major strikes. In order to obtain this type of simulation, cards of type #4 are required, in addition to card #1 (and cards of type #2, if plots are desired). On card #1, the number of these exogenous shifts is specified as ISHIFT (columns 11-12). Then, a card of type #3 is required for each of these exogenous changes.

For example, suppose that, as a result of non-economic factors, the primary production of copper from the centrally planned countries is expected to be 5% above the level predicted otherwise. Suppose that this effect begins in 1981 and continues through the end of the simulation period - 1990. If a line printer format is desired, with no plots, the necessary cards (or statements) would be as shown in Illustration 14. The resulting simulation is presented in Illustration 15.

Illustration 15

Note: Illustration 15 is presented on pages 98 through 100. Each page represents one page of computer output in its original format. For clarity in this publication, the type has been reset.

```
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COPPER
ASSUMPTIONS
RATES OF CHANGE

	Income	Interest Rate	Money Growth Rate	Capital Acquisition
North America	2.76	5.12	5.31	3.85
South America	2.93	0.0	0.0	6.93
Asia	4.50	0.0	0.0	12.19
Africa	1.83	0.0	0.0	7.45
Europe	3.30	3.13	9.09	3.93
Oceania	2.65	4.08	7.98	4.38
Central Planned	5.45	0.0	0.0	0.0

Substitute Metal – Aluminum
Rate of Price Change -0.10

The Following External Shock Effects Have Been Used.

	North America		South America		Asia		Africa		Europe		Oceania		Centrally Planned	
Year	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand	Supply	Demand
1981	2486.8	2504.9	1365.0	463.8	469.4	1543.2	1744.2	109.1	185.2	3236.1	458.0	151.5	1917.1	2328.5
1982	2658.3	2567.9	1391.8	489.5	465.1	1586.8	1798.0	117.7	195.1	3337.7	489.5	158.7	2056.5	2469.5
1983	2858.0	2636.8	1417.2	511.8	469.1	1713.7	1846.0	127.3	205.8	3427.6	525.3	164.7	2201.4	2608.6
1984	3049.5	2712.8	1448.8	544.5	478.6	1821.7	1895.5	138.5	217.3	3563.3	564.8	172.1	2347.0	2754.4
1985	3258.0	2814.6	1479.0	576.5	493.9	1941.6	1947.9	150.6	229.7	3700.6	607.2	180.2	2494.5	2908.3
1986	3466.3	2921.3	1507.2	607.9	515.0	2061.5	2000.7	162.9	243.0	3831.0	651.4	188.5	2644.9	3070.2
1987	3674.1	3025.3	1534.0	638.8	542.1	2187.5	2053.5	175.4	257.0	3956.7	697.3	196.6	2798.6	3239.5
1988	3883.7	3127.7	1560.9	671.3	575.0	2319.6	2107.0	188.2	271.7	4088.6	745.2	205.0	2955.0	3417.2
1989	4099.1	3234.9	1588.3	705.8	613.5	2458.3	2162.1	201.3	287.3	4229.5	795.3	213.7	3113.0	3604.7
1990	4320.8	3349.5	1615.5	741.6	657.5	2602.8	2218.7	214.5	303.6	4376.7	847.5	222.8	3272.6	3802.9

SECONDARY PRODUCTION

Year	North America	South America	Asia	Africa	Europe	Oceania	Centrally Planned
1981	481.1	57.8	125.5	0.0	481.5	36.1	N/A
1982	483.9	63.6	148.0	0.0	517.3	38.4	N/A
1983	483.2	68.2	152.5	0.0	536.8	39.4	N/A
1984	489.4	73.2	163.1	0.0	555.7	41.4	N/A
1985	503.0	78.4	172.4	0.0	574.1	43.1	N/A
1986	521.8	84.2	182.7	0.0	596.9	45.0	N/A
1987	541.6	90.4	192.8	0.0	621.3	47.3	N/A
1988	561.6	96.8	203.4	0.0	645.8	49.7	N/A
1989	582.8	103.3	214.5	0.0	670.6	52.2	N/A
1990	606.3	110.2	226.4	0.0	696.9	54.8	N/A

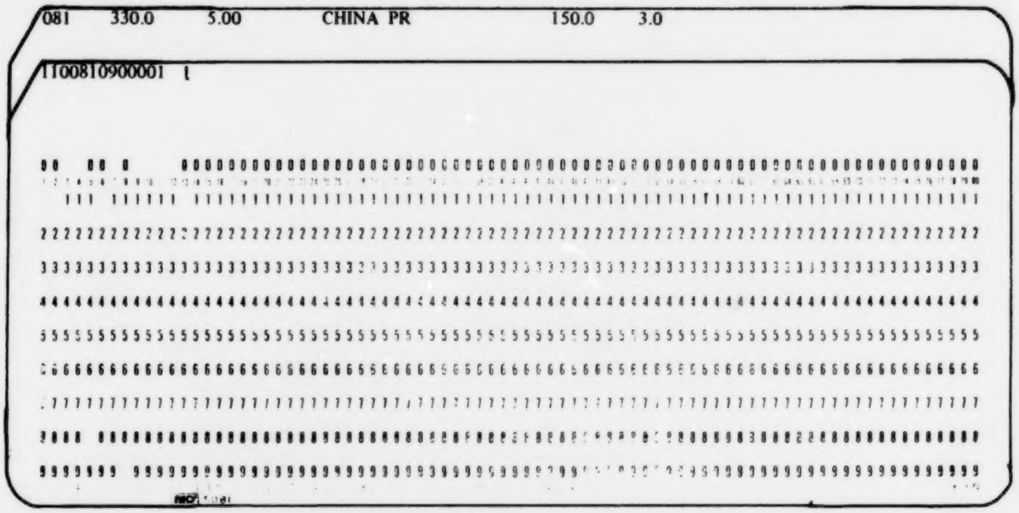
WORLD

Year	Production	Scrap	Consumption	Price
1981	8625.7	1181.9	10337.0	96.220
1982	9054.3	1251.3	10727.8	100.581
1983	9522.8	1280.1	11190.5	96.636
1984	10001.5	1322.9	11707.3	95.564
1985	10510.1	1370.9	12272.4	97.418
1986	11028.5	1430.7	12843.3	100.880
1987	11556.6	1493.4	13419.8	103.634
1988	12098.5	1557.2	14017.6	105.704
1989	12658.6	1623.5	14648.1	108.052
1990	13236.2	1694.6	15310.8	111.342

6.5 THE ADVENT OF NEW SOURCES OF CONSUMPTION AND/OR PRODUCTION

An area that may be of substantial interest to persons involved in the mineral markets is the effect of the entry of new consumers or producers. Examples include the entry of China into the world market and the development of deep-seabed mining. In order to obtain simulations under such assumptions, cards of type #5 are required, in addition to card #1 (and, if plots are desired, cards of type #2). On card #1, the number of additional producers and/or demanders is entered as IEXTRA (column 13). Then, a card of type #5 is required for *each* of the new "country groups".

For example, suppose that it is assumed that the People's Republic of China enters the world copper market in 1981. Assume that the initial level of consumption is 330.0 thousand metric tons and the initial level of production is 150.0 thousand metric tons. Assuming further that the expected annual growth rates of consumption and production are respectively 5% and 3%, the necessary simulation cards for a forecast from 1981 to 1989 in a line-printer format with no plots would be shown in Illustration 16. The resulting simulations are presented in Illustration 17.



081 330.0 5.00 CHINA PR 150.0 3.0

1100810900001 1

Illustration 16

Illustration 17

Note: Illustration 17 is presented on pages 103 through 109. Each page represents one page of computer output in its original format. For clarity in this publication, the type has been reset.

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COPPER
ASSUMPTIONS
RATES OF CHANGE

	Income	Interest Rate	Money Growth Rate	Capital Acquisition
North America	2.76	5.12	5.31	3.85
South America	2.93	0.0	0.0	6.93
Asia	4.50	0.0	0.0	12.19
Africa	1.83	0.0	0.0	7.45
Europe	3.30	3.13	9.09	3.93
Oceania	2.65	4.08	7.98	4.38
Central Planned	5.45	0.0	0.0	0.0
China Pr	0.0	0.0	0.0	0.0

Substitute Metal – Aluminum
Rate of Price Change -0.10

NORTH AMERICA

Year	Supply	Scrap	Demand	Price
1981	2653.8	481.1	2504.9	96.220
1982	2871.7	490.0	2582.6	105.256
1983	3031.6	497.6	2670.4	106.844
1984	3172.4	518.6	2774.1	116.200
1985	3328.0	551.3	2911.8	131.025
1986	3479.2	589.1	3046.6	146.962
1987	3628.9	625.9	3170.2	160.778
1988	3784.5	661.7	3290.5	173.307
1989	3952.1	699.0	3418.1	186.335

ASIA

Year	Supply	Scrap	Demand	Price
1981	477.0	125.5	1543.2	96.220
1982	478.5	149.1	1586.8	105.256
1983	487.6	154.5	1709.5	106.844
1984	500.3	167.0	1814.2	116.200
1985	516.9	178.6	1926.0	131.025
1986	537.9	190.8	2037.3	146.962
1987	563.7	202.7	2155.5	160.778
1988	594.0	215.0	2280.8	173.307
1989	628.6	228.1	2412.7	186.335

SOUTH AMERICA

Year	Supply	Scrap	Demand	Price
1981	1365.0	57.8	463.8	96.220
1982	1392.6	64.2	493.1	105.256
1983	1415.6	69.7	514.9	106.844
1984	1444.7	76.6	550.8	116.200
1985	1469.5	84.1	583.2	131.025
1986	1490.2	92.7	612.9	146.962
1987	1509.5	101.6	642.1	160.778
1988	1529.9	110.7	673.9	173.307
1989	1551.3	119.8	708.1	186.335

AFRICA

Year	Supply	Scrap	Demand	Price
1981	1761.4	0.0	109.1	96.220
1982	1819.7	0.0	117.3	105.256
1983	1870.5	0.0	125.5	106.844
1984	1924.9	0.0	134.1	116.200
1985	1982.1	0.0	141.6	131.025
1986	2038.5	0.0	147.5	146.962
1987	2093.9	0.0	152.2	160.778
1988	2150.2	0.0	156.2	173.307
1989	2208.4	0.0	159.7	186.335

EUROPE

Year	Supply	Scrap	Demand	Price
1981	187.8	481.5	3236.1	96.220
1982	199.6	523.8	3348.3	105.256
1983	212.3	552.0	3429.8	106.844
1984	226.0	589.4	3562.7	116.200
1985	240.9	631.2	3681.2	131.025
1986	256.6	679.9	3778.8	146.962
1987	273.1	729.3	3870.1	160.778
1988	290.3	777.0	3973.1	173.307
1989	308.4	824.0	4088.7	186.335

CENTRAL PLANNED

Year	Supply	Scrap	Demand	Price
1981	1825.8	0.0	2328.5	96.220
1982	1868.2	0.0	2472.8	105.256
1983	1912.9	0.0	2615.9	106.844
1984	1955.8	0.0	2769.3	116.200
1985	2000.8	0.0	2932.9	131.025
1986	2050.6	0.0	3104.5	146.962
1987	2105.3	0.0	3283.1	160.778
1988	2163.9	0.0	3470.1	173.307
1989	2225.3	0.0	3667.1	186.335

OCEANIA

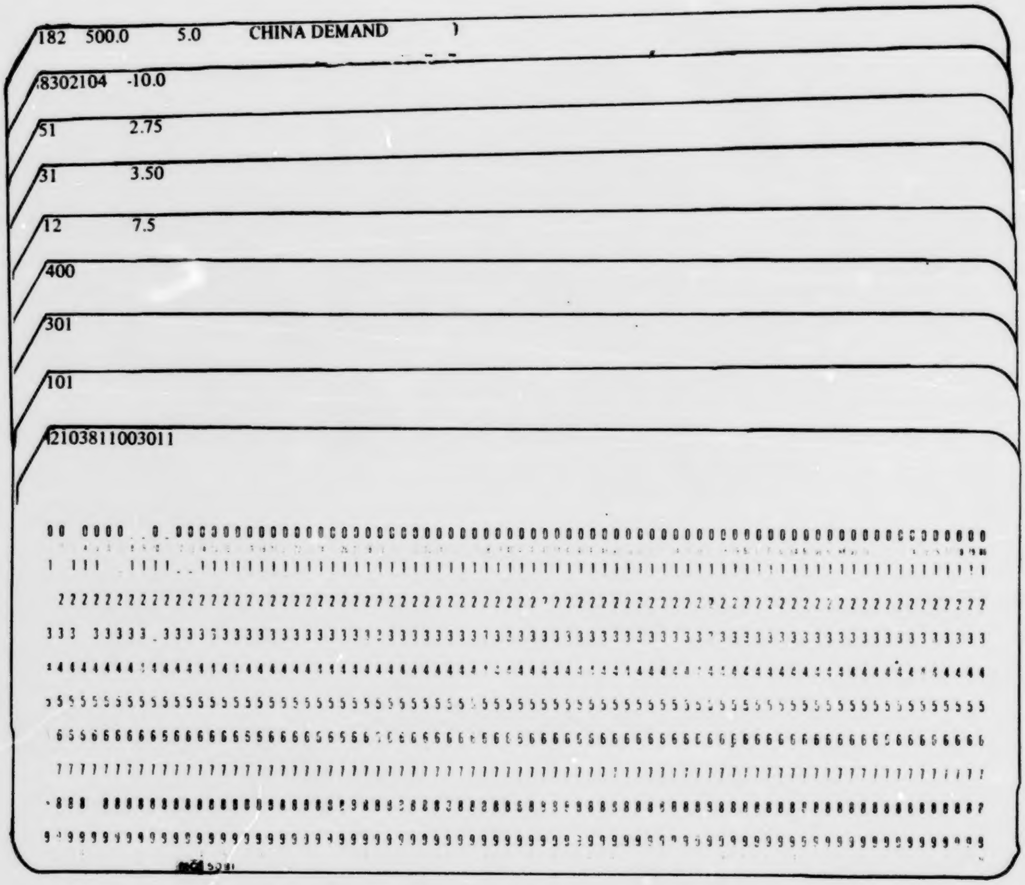
Year	Supply	Scrap	Demand	Price
1981	466.9	36.1	151.5	96.220
1982	502.6	39.0	159.6	105.256
1983	540.6	40.7	166.1	106.844
1984	579.8	44.6	174.9	116.200
1985	618.7	48.5	184.3	131.025
1986	656.1	53.1	193.5	146.962
1987	692.8	58.2	202.3	160.778
1988	729.7	63.5	211.3	173.307
1989	767.6	68.7	220.9	186.335

CHINA PR

Year	Supply	Scrap	Demand	Price
1981	150.0	0.0	330.0	96.220
1982	154.5	0.0	346.5	105.256
1983	159.1	0.0	363.8	106.844
1984	163.9	0.0	382.0	116.200
1985	168.8	0.0	401.1	131.025
1986	173.9	0.0	421.2	146.962
1987	179.1	0.0	442.2	160.778
1988	184.5	0.0	464.3	173.307
1989	190.0	0.0	487.6	186.335

WORLD

Year	Production	Scrap	Consumption	Price
1981	8887.8	1181.9	10667.0	96.220
1982	9287.4	1266.2	11107.0	105.256
1983	9630.2	1314.5	11595.9	106.844
1984	9967.9	1396.1	12162.1	116.200
1985	10325.8	1493.6	12762.2	131.025
1986	10683.0	1605.6	13342.3	146.962
1987	11046.3	1717.6	13917.7	160.778
1988	11427.0	1827.8	14520.1	173.307
1989	11831.8	1939.7	15162.8	186.335



```
182   500.0       5.0       CHINA DEMAND
8302104   -10.0
51           2.75
31           3.50
12           7.5
400
301
101
2103811003011
```

Illustration 18

6.6 COMBINATIONS OF CHANGES

From the preceding, it should be clear that this model will permit simulations that incorporate combinations of the changes described in sections 6.2-6.5. Perhaps the best way to describe such a simulation would be to provide an example.

Suppose that one desired a forecast for the aluminum market for the period 1981-1991 that incorporates the following assumptions:

- the interest rate in North America will rise to 7.5%
- the rate of growth of income in Asia will decline to 3.5%
- the rate of growth of income in Europe will decline to 2.75%
- due to political instability, production in South America will be 10% below that normally forth coming for the period 1983-1986
- China will consume 500.0 thousand metric tons in 1982 and this consumption will grow at an annual rate of 5%

Suppose further that a CRT format is desired with plots for primary production and consumption in North America and world price. The required simulation cards are shown in Illustration 18. Note that card #1 is the control card. Cards #2-4 specify the plots. Cards #5-7 specify the changes in the exogenous variables. The eighth card gives the exogenous change in production from South America and the ninth card denotes the entry of China. The resulting output is presented in Illustration 19.

Illustration 19

Note: Illustration 19 is presented on pages 110 through 117. Each page represents one page of computer output in its original format. For clarity in this publication, the type has been reset and the graphs have been redrawn with data points connected.

```
                              LIST OF DATA CARDS
RULE  1234567810_234567820_234567830_234567840_234567850_234567860_234567870_234567880
      21 38110 3 11
      1 1
      3 1
      4 9
      12       7.499999
      31       3.500000
      51       2.750000
      83 21 4  -10.0000
      182  500.0000     5.0000  CHINA DEMAND      0.0        0.0
```

ALUMINUM
ASSUMPTIONS
RATES OF CHANGE

	Income	Interest Rate	Money Growth Rate	Capital Acquisition
North America	2.76	7.50	5.31	3.85
South America	2.93	0.0	0.0	6.93
Asia	3.50	0.0	0.0	12.19
Africa	1.83	0.0	0.0	7.45
Europe	2.75	3.13	9.09	3.93
Oceania	2.65	4.08	7.98	4.38
Central Planned	5.45	0.0	0.0	0.0
China Demand	0.0	0.0	0.0	0.0

Substitute Metal – Copper
Rate of Price Change 3.55

The Following Growth Rates Have Been Altered.

Country Group	Variable	Rate
North America	Interest	7.7
Asia	Income	3.5
Europe	Income	2.7

The Following External Shock Effects Have Been Used.

Country Group	Percentage Equation	Shift	Initial Year	Final Year
South America	Supply	-10.00	83	87

NORTH AMERICA

Year	Supply	Scrap	Demand	Price
1981	6048.3	1657.4	6302.6	55.683
1982	6195.2	1721.9	6641.7	56.436
1983	6473.9	1801.4	6994.2	58.702
1984	6675.2	1892.0	7360.8	62.039
1985	6923.9	1991.8	7740.8	66.026
1986	7186.8	2099.3	8133.2	70.454
1987	7451.3	2213.6	8537.1	75.286
1988	7598.2	2334.0	8952.4	80.630
1989	7763.5	2460.3	9379.6	86.545
1990	7957.0	2592.2	9819.2	93.089

SOUTH AMERICA

Year	Supply	Scrap	Demand	Price
1981	1223.4	75.7	563.5	55.683
1982	1549.9	73.0	590.9	56.436
1983	1661.3	79.6	630.5	58.702
1984	1778.1	84.5	658.4	62.039
1985	1901.2	88.2	690.2	66.026
1986	2031.1	92.0	722.4	70.454
1987	2409.8	95.7	754.5	75.286
1988	2766.4	98.4	779.3	80.630
1989	3113.3	100.9	807.7	86.545
1990	3460.3	104.0	837.8	93.089

ASIA

Year	Supply	Scrap	Demand	Price
1981	1813.4	777.6	2608.6	55.683
1982	1958.3	810.7	2744.4	56.436
1983	2124.2	847.7	2887.8	58.702
1984	2299.8	888.1	3036.6	62.039
1985	2488.7	931.4	3190.8	66.026
1986	2692.1	977.5	3350.3	70.454
1987	2910.6	1026.0	3515.4	75.286
1988	3144.2	1076.8	3686.4	80.630
1989	3394.3	1129.9	3863.3	86.545
1990	3661.5	1185.1	4046.3	93.089

AFRICA

Year	Supply	Scrap	Demand	Price
1981	429.0	16.8	178.5	55.683
1982	477.3	17.3	188.9	56.436
1983	525.5	17.9	197.7	58.702
1984	575.5	18.5	208.5	62.039
1985	628.0	19.3	219.2	66.026
1986	683.4	20.2	230.2	70.454
1987	742.0	21.2	241.6	75.286
1988	803.9	22.4	254.5	80.630
1989	869.4	23.7	267.2	86.545
1990	938.6	25.1	280.1	93.089

EUROPE

Year	Supply	Scrap	Demand	Price
1981	4368.4	1271.9	3885.5	55.638
1982	4755.1	1320.8	4046.8	56.436
1983	5139.4	1369.2	4198.7	58.702
1984	5513.3	1424.9	4370.3	62.039
1985	5893.4	1484.9	4549.4	66.026
1986	6290.7	1549.5	4737.1	70.454
1987	6709.4	1618.3	4933.5	75.286
1988	7160.8	1694.1	5150.1	80.630
1989	7636.0	1773.9	5375.1	86.545
1990	8135.9	1857.5	5606.4	93.089

CENTRAL PLANNED

Year	Supply	Scrap	Demand	Price
1981	3783.1	0.0	3378.4	55.683
1982	3976.8	0.0	3637.8	56.436
1983	4222.6	0.0	3882.4	58.702
1984	4461.7	0.0	4141.1	62.039
1985	4701.6	0.0	4407.6	66.026
1986	4957.3	0.0	4685.8	70.454
1987	5223.8	0.0	4978.1	75.286
1988	5532.5	0.0	5295.8	80.630
1989	5831.1	0.0	5630.8	86.545
1990	6146.8	0.0	5982.5	93.089

OCEANIA

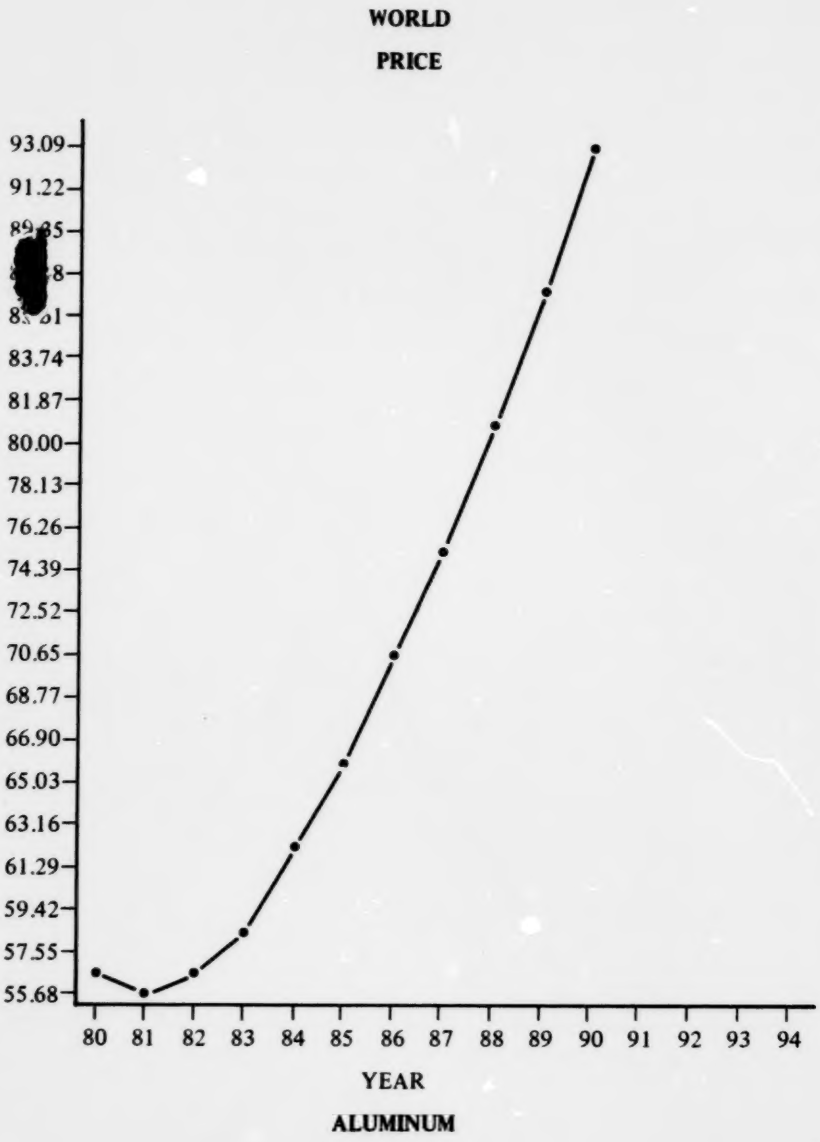
Year	Supply	Scrap	Demand	Price
1981	517.9	42.3	229.0	55.683
1982	584.9	45.6	241.4	56.436
1983	654.2	46.4	253.9	58.702
1984	730.5	48.3	266.9	62.039
1985	813.6	50.6	280.1	66.026
1986	903.5	53.2	293.8	70.454
1987	1000.1	56.0	307.7	75.286
1988	1105.2	58.8	322.2	80.630
1989	1217.8	61.8	337.0	86.545
1990	1337.6	64.8	352.2	93.089

CHINA DEMAND

Year	Supply	Scrap	Demand	Price
1981	0.0	0.0	0.0	55.683
1982	0.0	0.0	500.0	56.436
1983	0.0	0.0	525.0	58.702
1984	0.0	0.0	551.2	62.039
1985	0.0	0.0	578.8	66.026
1986	0.0	0.0	607.8	70.454
1987	0.0	0.0	638.1	75.286
1988	0.0	0.0	670.0	80.630
1989	0.0	0.0	703.5	86.545
1990	0.0	0.0	738.7	93.089

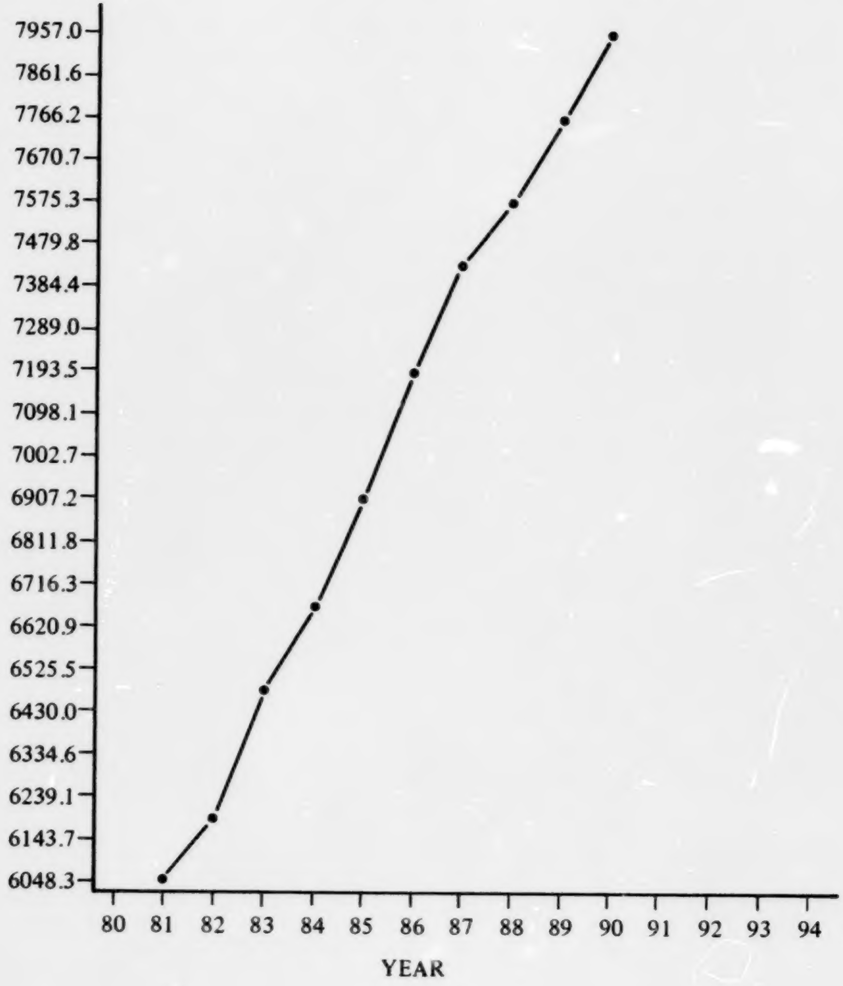
WORLD

Year	Production	Scrap	Consumption	Price
1981	18183.4	3841.6	17146.1	55.683
1982	19497.5	3989.4	18592.0	56.436
1983	20801.0	4162.2	19570.2	58.702
1984	22034.1	4356.3	20593.9	62.039
1985	23350.2	4566.2	21657.1	66.026
1986	24744.9	4791.7	22760.5	70.454
1987	26446.9	5030.8	23906.1	75.286
1988	28111.2	5284.6	25110.8	80.630
1989	29825.4	5550.5	26364.2	86.545
1990	31637.7	5828.7	27663.2	93.089

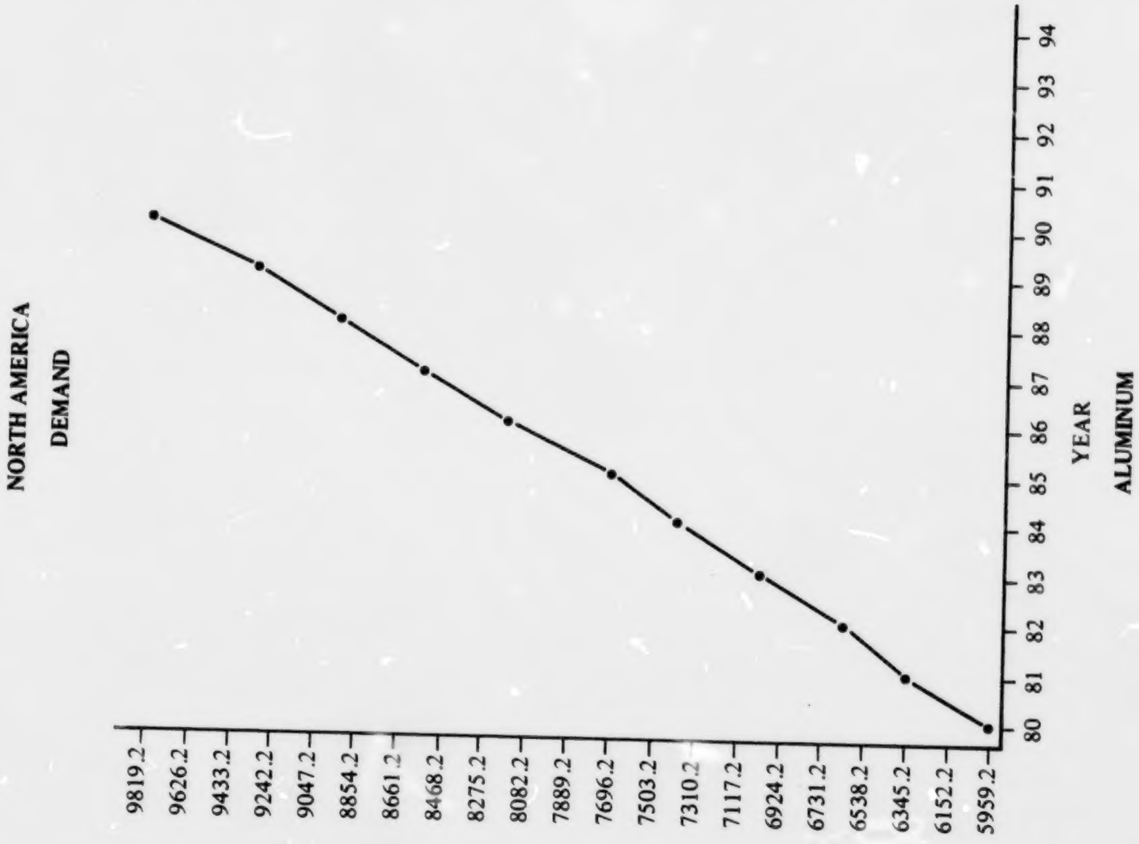

WORLD
PRICE
93.09
91.22
89.35
83.74
81.87
80.00
78.13
76.26
74.39
72.52
70.65
68.77
66.90
65.03
63.16
61.29
59.42
57.55
55.68
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
YEAR
ALUMINUM

NORTH AMERICA

SUPPLY



ALUMINUM


NORTH AMERICA
DEMAND
9819.2
9626.2
9433.2
9242.2
9047.2
8854.2
8661.2
8468.2
8275.2
8082.2
7889.2
7696.2
7503.2
7310.2
7117.2
6924.2
6731.2
6538.2
6345.2
6152.2
5959.2
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
YEAR
ALUMINUM

- 7 -

POTENTIAL EXTENSIONS

Based on the evaluation of the simulation model presented in Chapter 4, the approach employed in this project appears to be justifiable. A market-oriented, supply-demand model that explicitly incorporates the dynamic nature of the mineral markets and permits the existence of disequilibrium apparently can successfully forecast future consumption and price, under alternative assumptions about future world economic and political conditions. However, as with any model, this approach can be improved upon. In this very brief chapter, some of the potential extensions and refinements will be noted.

Obviously, one extension would involve the estimation and simulation of additional mineral commodities. The same basic techniques might be used to examine, say, cobalt or steel. However, for some minerals, the techniques might have to be modified to more accurately reflect the characteristics of the specific market. Such modifications might be along the lines of the techniques used in this project to model the purported dominant-firm price-leader in nickel.

With respect to the econometric model itself, extensions and refinements might be made in the price series used, in decomposition of the consumption data, and in the incorporation of simultaneity. In this project, the price series used might best be regarded as "posted" prices. Although it is felt that the use of such series is justifiable on both theoretical and pragmatic grounds, it would be informative to use, as an alternative, the "spot" prices for the mineral commodities. As Banks (1979) has argued, spot prices might more accurately reflect the workings of the market.

In this study, demand was defined in terms of total consumption by a country group. Thus, the model considered, say, the demand for aluminum by North America. More realistically, there are different categories of demanders of aluminum in North America — e.g., demand from manufacturers, demand from packaging firms, and demand from the electronics industry. It could be extremely informative to decompose total demand (or consumption) into its components and estimate several demand functions for each of the industrialized country groups. Such a decomposition could have several advantages. For example, although aluminum and copper may be substitutes in general, they are not in the packaging firms and the inclusion of the price of copper in such a demand function may introduce bias. Also, it is expected that the different demand functions should exhibit very different elasticities — e.g., the demand for aluminum in manufacturing should be far more responsive to changes in income than the demand from packaging firms.

The simultaneity inherent in these markets could possibly be more completely incorporated. The systems of demand and supply functions may be able to be estimated simultaneously, perhaps by using three-stage least squares rather than two-stage least squares. Using such a technique could eliminate the need for the search procedure to finalize the simulation model. Furthermore, the simultaneity between mineral markets could be considered. It might be possible to simultaneously estimate, say, the copper and aluminum markets.

A final potential extension involves the addition of a time-series model to the econometric model developed in this project. As has been argued, the authors feel that an econometric model is far more appropriate for long-run forecasting. However, it might be useful to have available a time-series model that could be used to provide short-run price and consumption forecasts.

APPENDIX A
PROGRAM LISTING AND DESCRIPTION

The program processes information in the following general manner.

1. User-supplied data is inputted. The program processes this information making the appropriate changes in the program parameters.

2. The program iterates to simulate world price, individual country group consumption, individual country group secondary production, and individual country group primary production. The country group values for consumption, primary production, and secondary consumption are then summed to obtain the world values. The MAIN program does the preceding calculations, obtaining the world values immediately after calculating the individual country group values — e.g., after all country group consumption values are calculated, world consumption (demand) is calculated. To calculate price, MAIN calls the function PRCADD. To calculate the values for the individual country groups, MAIN calls the function GENADD. After all of the values have been calculated for a particular year, the values are copied to the array OUTPUT. Then, the values are updated to permit calculation of the next period's values.

3. After the iterations are complete, MAIN adjusts the prices to be in terms of 1979 U.S. dollars. Then, calls are made to CRTPRT and/or LINPRT to print the output and to PLOT for plotting.

```
C***********************************************************************
C                                                                      *
C        MAIN PROGRAM                                                  *
C                                                                      *
C        THE MAIN PROGRAM READS AND PROCESSES USER ALTERATIONS TO THE *
C   FOLLOWING:                                                         *
C                                                                      *
C   1. PRINT OPTIONS                                                   *
C   2. PLOT OPTIONS                                                    *
C   3. GROWTH RATES OF EXOGENEOUS VARIABLES                            *
C   4. EXOGENEOUS SHOCKS TO SIMULATED DATA.                            *
C   5. EXTRA COUNTRY GROUPS                                            *
C                                                                      *
C        IT THEN ITERATES TO OBTAIN SIMULATED VALUES FOR               *
C   THE MINERAL PRICE, DEMAND, SCRAP PRODUCTION. AND                   *
C   PRIMARY PRODUCTION.  IN ADDITION IT CALCULATES THE WORLD           *
C   TOTALS FOR THESE VARIABLES.                                        *
C                                                                      *
C        MAIN THEN MAKES CALLS TO CRTPRT AND LINPRT FOR                *
C   PRINTING, AND MAKES CALLS TO PLOT FOR PLOTTING.                    *
C                                                                      *
C***********************************************************************
      COMMON / ARPRIC / PRICE(2,3,4)                                    MAIN001
      COMMON / AREOUT / OUTPUT (4,11,25), DOTVAR (4,10), PRDCT (4),     MAIN002
     1 ICNT(25), IGRT(25), USRGRT(25), GROW(25)                         MAIN003
      COMMON / AREAPR / PRCOEF(15,4),PSHIFT(50),PRCHA(4)                MAIN004
      COMMON / AREEXP / EXPARM(2,4,10),WPI                              MAIN005
      COMMON / AREAGN / DMCOEF(15,10,4), SRCOEF(15,10,4),               MAIN006
     1 SPCOEF(15,10,4), SHFT(50,30)                                     MAIN007
      COMMON / AREDAT / QDEM(4,10,4), QSUP(2,10,4), QSCP(2,10,4),       MAIN008
     .      QSPROD(2,10,4)                                              MAIN009
      COMMON / AREANM / NAME (2,4),  NAMSUB (2,4),  NAMCNT (4,11),      MAIN010
     1  NAMEXT(2,5),NAMVAR(2,4), IYRSFT(20), SHIFT(20), ICTSHT(20),     MAIN011
     2  IVETLB(22,4),ISTAR,IBLANK,IMATCH,IBAR,IPLTVR(3,12),IPLTPR       MAIN012
      COMMON/ AREPRM/ ICNTRY, IYR, IPRICE, IQDEM, IQSUP, IQSCP, IYRSIM, MAIN013
     . IYRFST, NIKCHK,  IWORLD, IANN, IEXCHK, INEW(3), IERROR(14),IPG,  MAIN014
     2 ISVAR(20), ISLEN(20), KVAR(3), IEXTRA, CNEW(3,4), ISCALE(30)     MAIN015
      DIMENSION CHANGE(6,10)                                            MAIN016
      DIMENSION WORDEM(4,4), WORSUP(2,4), WORSCP(2,4), WSSUM(3,4)       MAIN017
      DIMENSION ROWS(3,10,4)                                            MAIN018
      DIMENSION NAM(4)                                                  MAIN019
      WRITE (6,1050)                                                    MAIN020
      WRITE (6,1050)                                                    MAIN021
C***********************************************************************
C                                                                      *
C     READ USER COMMANDS                                               *
C                                                                      *
C     IMINRL = CODE # OF MINERAL TO SIMULATE                           *
C                = 1 IF COPPER.                                        *
C                = 2 IF ALUMINUM.                                      *
C                = 3 IF NICKEL.                                        *
C                = 4 IF ZINC.                                          *
C                = 5 IF NICKEL-MODIFIED CASE.                          *
C     IPRTCT = CODE # OF PRINT OPTIONS                                 *
C                = 0  IF ONLY CRT.                                     *
C                = 1  IF ONLY LINE PRINTER.                            *
C                = 2  IF BOTH.                                         *
C     IPLOT  = # OF PLOT OPTION CARDS                                  *
C     IFSTYR = FIRST YEAR TO BE PRINTED.                               *
C     ISIMYR = # OF YEARS TO SIMULATE                                  *
```

```
C      IGROW  = # OF GROWTH RATES TO BE ALTERED
C      ISHIFT = # OF EXOGENEOUS SHIFT CARDS.                              *
C      IEXTRA = # OF ADDITIONAL COUNTRY GROUPS.                           *
C                                                                         *
C              IGROW SHOULD BE 0(ZERO) IF NO OPTION                       *
C      CARDS ARE USED TO ALTER GROWTH RATES.                              *
C              ISHIFT SHOULD BE 0(ZERO) IF NO OPTION                      *
C      CARDS ARE USED TO SPECIFY EXOGENEOUS SHIFTS.                       *
C              IEXTRA SHOULD BE 0(ZERO) IF NO OPTION                      *
C      CARDS ARE USED TO SPECIFY ADDITIONAL COUNTRY GROUPS.               *
C                                                                         *
C      FORMAT  2I1,5I2,I1                                                 *
C                                                                         *
C*************************************************************************
      READ (5,1000) IMINRL,IPRTCT,IPLOT,IFSTYR,ISIMYR,IGROW,ISHIFT,
     1 IEXTRA                                                             MAIN022
      WRITE (6,1080) IMINRL,IPRTCT,IPLOT,IFSTYR,ISIMYR,IGROW,ISHIFT,      MAIN023
     1 IEXTRA                                                             MAIN024
      IF (ISIMYR.NE.0) IYRSIM=ISIMYR                                      MAIN025
      IF (IFSTYR.NE.0) IYRFST=IFSTYR                                      MAIN026
      IF (IMINRL.LT.0.OR.IMINRL.GT.5) IERROR(1)=1                         MAIN027
      IF (IPRTCT.LT.0.OR.IPRTCT.GT.3) IERROR(2)=1                         MAIN028
      IF (IYRSIM.LT.0) IERROR(3)=1                                        MAIN029
      IF (IGROW.LT.0) IERROR(4)=1                                         MAIN030
      IF (ISHIFT.LT.0) IERROR(5)=1                                        MAIN031
      IF (IEXTRA.LT.0.OR.IEXTRA.GT.3) IERROR(6)=1                         MAIN032
      IF (IPLOT.LT.0) IERROR(8)=1                                         MAIN033
      IERR=0                                                              MAIN034
      DO 10 I=1,8                                                         MAIN035
         IF (IERROR(I).NE.0) IERR=1                                       MAIN036
   10 CONTINUE                                                            MAIN037
      IF (IERR.NE.0) GO TO 550                                            MAIN038
      IPG=IGROW+ISHIFT                                                    MAIN039
      IYRPLT=IYRFST-1                                                     MAIN040
      IYRFST=IYRFST-IYR+1                                                 MAIN041
      IYRSIM=IYRSIM+IYRFST-1                                              MAIN042
      IYRMAX=IYR+IYRSIM-1                                                 MAIN043
      ICNTRY=ICNTRY+IEXTRA                                                MAIN044
      IWORLD=ICNTRY+1                                                     MAIN045
      IF (IMINRL.NE.5) GO TO 20                                           MAIN046
C************************************************************************ MAIN047
C                                                                         *
C              IF NICKEL-MODIFIED CASE IS BEING USED, RESET EQUATION      *
C      COEFFICEINTS TO APPROPRIATE VALUES.                                *
C                                                                         *
C*************************************************************************
      NIKCHK=1
      IMINRL=3                                                            MAIN048
      SPCOEF(5,1,3)=SPCOEF(5,6,3)                                         MAIN049
      SPCOEF(6,1,3)=SPCOEF(6,6,3)                                         MAIN050
      SPCOEF(7,1,3)=SPCOEF(7,6,3)                                         MAIN051
      UMCOEF(5,1,3)=0.0                                                   MAIN052
      UMCOEF(5,5,3)=0.0                                                   MAIN053
      UMCOEF(5,6,3)=0.0                                                   MAIN054
      PRCOEF(4,3)=-0.0292                                                 MAIN055
   20 CONTINUE                                                            MAIN056
      IANN=IYR+1899                                                       MAIN057
      IF (IPLOT.EQ.0) GO TO 90                                            MAIN058
C************************************************************************ MAIN059
C                                                                         *
```

```
C             IF PLOT OPTIONS HAVE BEEN CALLED FOR, READ                      *
C       PLOT OPTION CARDS.                                                    *
C                                                                             *
C       IVAR   = INDEX OF VARIABLE TO PLOT                                    *
C                   = 0 IF ALL VARIABLES                                      *
C                   = 1 IF PRIMARY PRODUCTION (SUPPLY)                        *
C                   = 2 IF SECONDARY PRODUCTION (SCRAP)                       *
C                   = 3 IF DEMAND                                             *
C                   = 4 IF PRICE.                                             *
C       ICTPLT = INDEX OF COUNTRY GROUP TO PLOT                               *
C                   = 0 IF WORLD                                              *
C                   = 1 IF NORTH AMERICA                                      *
C                   = 2 IF SOUTH AMERICA                                      *
C                   = 3 IF ASIA                                               *
C                   = 4 IF AFRICA                                             *
C                   = 5 IF EUROPE                                             *
C                   = 6 IF OCEANIA                                            *
C                   = 7 IF CENTRALLY PLANNED                                  *
C                   = 8,9,10 FOR ADDITIONAL COUNTRY GROUPS                    *
C                   = 12 FOR ALL COUNTRY GROUPS PLUS WORLD                    *
C                                                                             *
C       FORMAT  I2,I1                                                         *
C                                                                             *
C******************************************************************************
      DO 70 I=1,IPLOT
         READ (5,1010) IVAR,ICTPLT
         WRITE (6,1070) IVAR,ICTPLT
         ICHECK=ICTPLT
         IF (ICHECK.EQ.0) ICTPLT=IWORLD
         IF (ICHECK.EQ.12) ICTPLT=0
         IF (IVAR.EQ.0.OR.IVAR.EQ.4) IPLTPR=1
         IF (IVAR.EQ.4) GO TO 70
         IF (IVAR.NE.0) GO TO 50
         DO 40 J=1,3
            IF (ICTPLT.NE.0) IPLTVR(J,ICTPLT)=1
            IF (ICTPLT.NE.0) GO TO 40
            DO 30 K=1,IWORLD
               IPLTVR(J,K)=1
   30       CONTINUE
   40    CONTINUE
         GO TO 70
   50    CONTINUE
         IF (ICTPLT.NE.0) IPLTVR(IVAR,ICTPLT)=1
         IF (ICTPLT.NE.0) GO TO 70
         DO 60 K=1,IWORLD
            IPLTVR(IVAR,K)=1
   60    CONTINUE
   70 CONTINUE
      IPLTVR(2,7)=0
      IF (IMINRL.LE.2) GO TO 90
      IPLTVR(2,4)=0
      IF (IMINRL.EQ.1) GO TO 90
      DO 80 J=1,5
         K=J
         IF (J.GE.4) K=K+1
         IPLTVR(2,K)=0
   80 CONTINUE
   90 CONTINUE
      IF (IGROW.EQ.0) GO TO 130
C******************************************************************************
```

```
C      ICNT    = INDEX FOR COUNTRY GROUP
C                  SEE PLOT OPTIONS ABOVE FOR VALUES                    *
C                  NOTE THAT INCT=12 IS NOT VALID HERE.                 *
C      IGRT    = INDEX OF EXOGENEOUS VARIABLE TO HAVE GROWTH ALTERED.   *
C                      = 1 IF INCOME                                    *
C                      = 2 IF INTEREST RATE                             *
C                      = 3 IF CAPITAL STOCK                             *
C                      = 4 IF MONEY STOCK                               *
C                      = 5 IF PRICE OF RELATED GOOD.                    *
C      NOTE:    IF IGRT=5, THEN THE ONLY VALID VALUE FOR ICNT IS 0,     *
C           I.E. WORLD.                                                 *
C      USRGRT = NEW GROWTH RATE VALUE                                   *
C             TO BE ENTERED AS PERCENTAGE, 10.0 NOT .10 FOR TEN PERCENT. *
C      FORMAT  2I1,2P14.6                                               *
C                                                                       *
C************************************************************************
       READ (5,1020) (ICNT(I),IGRT(I),USRGRT(I),I=1,IGROW)
       WRITE (6,1090) (ICNT(I),IGRT(I),USRGRT(I),I=1,IGROW)             MAIN095
       DO 110 I=1,IGROW                                                 MAIN096
          IF (ICNT(I).LT.0.OR.ICNT(I).GT.ICNTRY) IERROR(9)=I            MAIN097
          IF (ICNT(I).EQ.0.AND.IGRT(I).NE.5) IERROR(10)=I               MAIN098
          IF (IGRT(I).LE.0.OR.IGRT(I).GE.6) IERROR(11)=I                MAIN099
          J=IGRT(I)                                                     MAIN100
          K=ICNT(I)                                                     MAIN101
          IF (J.EQ.5) GO TO 100                                         MAIN102
          IF (J.EQ.4) USRGRT(I)=USRGRT(I)*100.0                         MAIN103
          UGTVAR(J,K)=USRGRT(I)                                         MAIN104
          IF (J.LE.2) GO TO 110                                         MAIN105
          EXPARM(2,J,K)=USRGRT(I)                                       MAIN106
          GO TO 110                                                     MAIN107
  100     PRDOT(IMINRL)=USRGRT(I)                                       MAIN108
  110 CONTINUE                                                          MAIN109
      DO 120 J=9,11                                                     MAIN110
         IF (IERROR(J).NE.0) IERR=1                                     MAIN111
  120 CONTINUE                                                          MAIN112
      IF (IERR.NE.0) GO TO 550                                          MAIN113
  130 CONTINUE                                                          MAIN114
C***********************************************************************  MAIN115
C                                                                       *
C               READ SHIFT OPTION CARDS IF CALLED                       *
C                                                                       *
C      IYRSFT = 2-DIGIT VALUE FOR FIRST YEAR OF SHIFT.                  *
C      ICTSHT = INDEX OF COUNTRY GROUP TO SHIFT                         *
C                 SEE PLOT OPTIONS ABOVE FOR VALUE.                     *
C      NOTE:    NEITHER ICTSHT=0 NOR ICTSHT=12 ARE VALID.               *
C      ISVAR  = INDEX OF VARIABLE TO SHIFT.                             *
C                 SEE PLOT OPTIONS ABOVE.                               *
C      ISLEN  = # OF YEARS SHIFT WILL BE ACTIVE.                        *
C      SHIFT  = VALUE OF SHIFT---IN PERCENTAGE.                         *
C                                                                       *
C      FORMAT  2I2,I1,I2,2PF10.4                                        *
C                                                                       *
C************************************************************************
      IF (ISHIFT.EQ.0) GO TO 180
      DO 170 I=1,ISHIFT                                                 MAIN116
         READ (5,1040) IYRSFT(I),ICTSHT(I),ISVAR(I),ISLEN(I),SHIFT(I)   MAIN117
                                                                        MAIN118
      WRITE (6,1110) IYRSFT(I),ICTSHT(I),ISVAR(I),ISLEN(I),SHIFT(I)    MAIN119
      IYRS=IYRSFT(I)-IYR+1                                             MAIN120
      ILENGT=ISLEN(I)                                                  MAIN121
      IF (ILENGT.EQ.0) ILENGT=1                                        MAIN122
      ISTOP=IYRS+ILENGT-1                                              MAIN123
      IF (ISVAR(I).EQ.4) GO TO 150                                     MAIN124
      K=(KVAR(ISVAR(I))*10)+ICTSHT(I)                                  MAIN125
      DO 140 J=IYRS,ISTOP                                              MAIN126
         SHFT(J,K)=SHFT(J,K)+SHIFT(I)                                  MAIN127
  140 CONTINUE                                                         MAIN128
      GO TO 170                                                        MAIN129
  150 CONTINUE                                                         MAIN130
      DO 160 J=IYRS,ISTOP                                              MAIN131
         PSHIFT(J)=PSHIFT(J)+SHIFT(I)                                  MAIN132
  160 CONTINUE                                                         MAIN133
  170 CONTINUE                                                         MAIN134
  180 CONTINUE                                                         MAIN135
    IF (IEXTRA.EQ.0) GO TO 240                                         MAIN136
C*******************************************************************
C                                                                  *
C               READ EXTRA COUNTRY GROUP CARDS IF CALLED.          *
C                                                                  *
C     ITYPE  = 0 IF BOTH DEMANDER AND SUPPLIER                     *
C              1 IF ONLY DEMANDER                                  *
C              2 IF ONLY SUPPLIER.                                 *
C     IYRST  = 2-DIGIT VALUE FOR YEAR COUNTRY ENTERS MARKET        *
C     AMT1   = INITIAL VALUE OF DEMAND IF DEMANDER OR BOTH DEMANDER*
C                   AND SUPPLIER.                                  *
C            = INITIAL VALUE OF SUPPLY IF ONLY SUPPLIER.           *
C     GRT1   = GROWTH RATE OF AMT1 IN PERCENTAGE TERMS.            *
C     NAM    = NAME OF NEW COUNTRY                                 *
C              MAY CONTAIN UP TO 16 ALPHANUMERIC CHARACTERS.       *
C     AMT2   = INITIAL VALUE OF SUPPLY IF BOTH DEMANDER AND SUPPLIER.  *
C     GRT2   = GROWTH RATE OF AMT2 IN PERCENTAGE TERMS.            *
C                                                                  *
C     FORMAT  I1,I2,F10.4,2PF10.4,A16,F10.4,2PF10.4                *
C                                                                  *
C*******************************************************************
      K=8+IEXTRA                                                       MAIN137
      DO 190 I=1,4                                                     MAIN138
         NAMCNT(I,K)=NAMCNT(I,8)                                       MAIN139
  190 CONTINUE                                                         MAIN140
      DO 230 I=1,IEXTRA                                                MAIN141
         IF (IERROR(12).NE.0) GO TO 220                                MAIN142
         READ (5,1030) ITYPE,IYRST,AMT1,GRT1,(NAM(J),J=1,4),AMT2,GRT2  MAIN143
         WRITE (6,1100) ITYPE,IYRST,AMT1,GRT1,(NAM(J),J=1,4),AMT2,GRT2 MAIN144
         INEW(I)=IYRST                                                 MAIN145
         IF (IYRST.LT.IYR.OR.IYRST.GT.IYRMAX) IERROR(12)=IYRST         MAIN146
         K=7+I                                                         MAIN147
         DO 200 J=1,4                                                  MAIN148
            NAMCNT(J,K)=NAM(J)                                         MAIN149
  200    CONTINUE                                                      MAIN150
         IF (ITYPE.EQ.2) GO TO 210                                     MAIN151
         CNEW(I,1)=AMT1                                                MAIN152
         CNEW(I,2)=GRT1                                                MAIN153
         IF (ITYPE.EQ.1) GO TO 220                                     MAIN154
         CNEW(I,3)=AMT2                                                MAIN155
         CNEW(I,4)=GRT2                                                MAIN156
         GO TO 220                                                     MAIN157
  210    CONTINUE                                                      MAIN158
```

```
            CNEW(I,3)=AMT1
            CNEW(I,4)=GRT1
  220       CONTINUE
  230 CONTINUE
      IF (IERROR(12).NE.0) GO TO 550
  240 CONTINUE
C***************************************************************
C                                                              *
C     CALCULATE RATE OF CHANGE MULTIPLIER                      *
C                                                              *
C***************************************************************
      DO 250 I=1,2
      DO 250 J=1,ICNTRY
         CHANGE(I,J)=1.0+DOTVAR(I,J)
  250 CONTINUE
      PRCHA(IMINRL)=1.0+PRODT(IMINRL)
      DO 260 I=3,4
      DO 260 J=1,ICNTRY
         CHANGE(I,J)=DOTVAR(I,J)
  260 CONTINUE
C***************************************************************
C                                                              *
C     CALCULATE WORLD VARIABLES                                *
C                                                              *
C***************************************************************
      DO 300 I=1,4
         WORDEM(I,IMINRL)=0.0
         IF (I.GE.3) GO TO 270
         WORSUP(I,IMINRL)=0.0
         WORSCP(I,IMINRL)=0.0
         WSSUM(I,IMINRL)=0.0
         IF (I.EQ.1) GO TO 300
  270    CONTINUE
         DO 280 J=1,ICNTRY
            WORDEM(I,IMINRL)=WORDEM(I,IMINRL)+QDEM(I,J,IMINRL)
            IF (I.GE.3) GO TO 280
            WORSUP(I,IMINRL)=WORSUP(I,IMINRL)+QSUP(I,J,IMINRL)
            WORSCP(I,IMINRL)=WORSCP(I,IMINRL)+QSCP(I,J,IMINRL)
            WSSUM(I,IMINRL)=WSSUM(I,IMINRL)+QSPROD(I,J,IMINRL)
  280    CONTINUE
         IF (I.GE.3) GO TO 300
         DO 290 J=1,ICNTRY
            ROWS(I,J,IMINRL)=WORSUP(I,IMINRL)-QSUP(I,J,IMINRL)
  290    CONTINUE
  300 CONTINUE
C***************************************************************
C                                                              *
C     CALCULATE CURRENT PERIOD EXOGENEOUS VARIABLES            *
C                                                              *
C***************************************************************
      PRICE(2,1,IMINRL)=PRICE(2,2,IMINRL)*PRCHA(IMINRL)
      DO 320 J=1,4
      DO 320 K=1,ICNTRY
         IF (J.LE.2) GO TO 310
         EXPARM(1,J,K)=CHANGE(J,K)
         GO TO 320
  310    EXPARM(1,J,K)=EXPARM(2,J,K)*CHANGE(J,K)
  320 CONTINUE
C***************************************************************
C                                                              *
```

```
C     NOW DO ITERATIONS TO SIMULATE FOR EACH YEAR                       *
C                                                                       *
C************************************************************************
      DO 500 ITER=1,IYRSIM                                              MAIN202
         IF (IEXCHK.GE.IEXTRA) GO TO 350                                MAIN203
         ICK=ITER+IYR-1                                                 MAIN204
C************************************************************************
C                                                                       *
C     CHECK IF NEW COUNTRY COMES ON LINE THIS YEAR. IF IT DOES          *
C  ALTER EQUATION PARAMETERS.                                           *
C                                                                       *
C************************************************************************
         DO 340 I=1,3                                                   MAIN205
            IF (INEW(I).NE.ICK) GO TO 330                               MAIN206
            K=7+I                                                       MAIN207
            DMCOEF(10,K,IMINRL)=1.0+CNEW(I,2)                           MAIN208
            SPCOEF(13,K,IMINRL)=1.0+CNEW(I,4)                           MAIN209
            XX=CNEW(I,1)/DMCOEF(10,K,IMINRL)                            MAIN210
            Y=CNEW(I,3)/SPCOEF(13,K,IMINRL)                             MAIN211
            QDEM(2,K,IMINRL)=XX                                         MAIN212
            QSUP(2,K,IMINRL)=Y                                          MAIN213
            IEXCHK=IEXCHK+1                                             MAIN214
  330       CONTINUE                                                    MAIN215
  340    CONTINUE                                                       MAIN216
  350    CONTINUE                                                       MAIN217
C************************************************************************
C                                                                       *
C     SET CURRENT VALUES TO ZERO                                        *
C                                                                       *
C************************************************************************
         DO 360 I=1,ICNTRY                                              MAIN218
            QDEM(1,I,IMINRL)=0.0                                        MAIN219
            QSCP(1,I,IMINRL)=0.0                                        MAIN220
            QSUP(1,I,IMINRL)=0.0                                        MAIN221
  360    CONTINUE                                                       MAIN222
         WORDEM(1,IMINRL)=0.0                                           MAIN223
         WORSUP(1,IMINRL)=0.0                                           MAIN224
         WORSCP(1,IMINRL)=0.0                                           MAIN225
         WSSUM(1,IMINRL)=0.0                                            MAIN226
         PRICE(1,1,IMINRL)=0.0                                          MAIN227
         YEAR=FLOAT(IYR+ITER-1)                                         MAIN228
         WOREX=WORSUP(2,IMINRL)+WORSCP(2,IMINRL)-WORDEM(2,IMINRL)       MAIN229
C************************************************************************
C                                                                       *
C   CALCULATE PRICE                                                     *
C                                                                       *
C************************************************************************
         PRICE(1,1,IMINRL)=PRCAJD(IPRICE,IMINRL,ITER,PRICE(1,2,IMINRL),  MAIN230
     1     PRICE(1,3,IMINRL),WOREX,WSSUM(2,IMINRL),YEAR,EXPARM(1,1,1),   MAIN231
     2     EXPARM(1,2,1),PRICE(2,1,IMINRL),PRICE(2,2,IMINRL),PRICE(2,3,  MAIN232
     3     IMINRL),0.0,0.0,0.0,0.0)                                     MAIN233
C************************************************************************
C                                                                       *
C   CALCULATE QUANTITY DEMANDED                                         *
C                                                                       *
C************************************************************************
         PDIF=PRICE(1,1,IMINRL)-PRICE(2,1,IMINRL)                       MAIN234
         PDIF1=PRICE(1,2,IMINRL)-PRICE(2,2,IMINRL)                      MAIN235
         PDIF2=PRICE(1,3,IMINRL)-PRICE(2,3,IMINRL)                      MAIN236
         WOREX2=WORSUP(2,IMINRL)-WORDEM(2,IMINRL)                       MAIN237
         DO 370 J=1,ICNTRY
            QDEM(1,J,IMINRL)=GENADD(IQDEM,J,IMINRL,1,ITER,PDIF,PDIF1,
     1         PDIF2,WOREX2,EXPARM(1,1,J),EXPARM(2,1,J),EXPARM(2,3,J),
     2         EXPARM(2,4,J),QDEM(2,J,IMINRL),0.0,0.0,0.0,0.0,0.0)
            WORDEM(1,IMINRL)=WORDEM(1,IMINRL)+QDEM(1,J,IMINRL)
  370    CONTINUE
C***********************************************************************
C                                                                      *
C     CALCULATE SCRAP                                                  *
C                                                                      *
C***********************************************************************
         DO 380 J=1,ICNTRY
            QSCP(1,J,IMINRL)=GENADD(IQSCP,J,IMINRL,2,ITER,PRICE(1,1,
     1         IMINRL),PRICE(1,2,IMINRL),PRICE(1,3,IMINRL),QDEM(1,J,
     2         IMINRL),QDEM(2,J,IMINRL),QDEM(3,J,IMINRL),QDEM(4,J,
     3         IMINRL),QSCP(2,J,IMINRL),WORDEM(1,IMINRL),WORDEM(2,
     4         IMINRL),WORDEM(3,IMINRL),WORDEM(4,IMINRL),0.0,0.0)
            WORSCP(1,IMINRL)=WORSCP(1,IMINRL)+QSCP(1,J,IMINRL)
  380    CONTINUE
C***********************************************************************
C                                                                      *
C     CALCULATE SUPPLY\                                                *
C                                                                      *
C***********************************************************************
         DO 390 J=1,ICNTRY
            QSUP(1,J,IMINRL)=GENADD(IQSUP,J,IMINRL,3,ITER,PRICE(1,1,
     1         IMINRL),PRICE(1,2,IMINRL),PRICE(1,3,IMINRL),ROWS(2,J,
     2         IMINRL),WORDEM(1,IMINRL),WORDEM(2,IMINRL),WORDEM(3,
     3         IMINRL),YEAR,EXPARM(1,2,J),EXPARM(2,2,J),QSPROD(2,J,
     4         IMINRL),QSUP(2,J,IMINRL),0.0,0.0)
            QSPROD(1,J,IMINRL)=QSPROD(2,J,IMINRL)+QSUP(2,J,IMINRL)
            WSSUM(1,IMINRL)=WSSUM(1,IMINRL)+QSPROD(1,J,IMINRL)
            WORSUP(1,IMINRL)=WORSUP(1,IMINRL)+QSUP(1,J,IMINRL)
  390    CONTINUE
         DO 400 I=1,ICNTRY
            ROWS(1,I,IMINRL)=WORSUP(1,IMINRL)-QSUP(1,I,IMINRL)
  400    CONTINUE
C***********************************************************************
C                                                                      *
C UPDATE OUTPUT ARRAY NEXT AND THEN UPDATE VARIABLE FOR NEXT ITERATION *
C                                                                      *
C***********************************************************************
         YEAR=YEAR+1900.0
         DO 410 J=1,ICNTRY
            OUTPUT(1,J,ITER)=QSUP(1,J,IMINRL)
            OUTPUT(2,J,ITER)=QSCP(1,J,IMINRL)
            OUTPUT(3,J,ITER)=QDEM(1,J,IMINRL)
            OUTPUT(4,J,ITER)=PRICE(1,1,IMINRL)
  410    CONTINUE
         OUTPUT(1,IWORLD,ITER)=WORSUP(1,IMINRL)
         OUTPUT(2,IWORLD,ITER)=WORSCP(1,IMINRL)
         OUTPUT(3,IWORLD,ITER)=WORDEM(1,IMINRL)
         OUTPUT(4,IWORLD,ITER)=PRICE(1,1,IMINRL)
         IF (IEXCHK.GT.IEXTRA) GO TO 430
         ICK=ITER+IYR-1
         DO 420 I=1,3
            IF (INEW(I).NE.ICK) GO TO 420
            K=7+I
            QDEM(2,K,IMINRL)=0.0
            QSUP(2,K,IMINRL)=0.0
  420    CONTINUE
  430    CONTINUE
         DO 480 I=1,3
            K=5-I
            L=K-1
            DO 460 J=1,ICNTRY
               IF (I.EQ.1) GO TO 450
               IF (I.EQ.2) GO TO 440
               QSUP(K,J,IMINRL)=QSUP(L,J,IMINRL)
               QSCP(K,J,IMINRL)=QSCP(L,J,IMINRL)
               QSPROD(K,J,IMINRL)=QSPROD(L,J,IMINRL)
  440          ROWS(K,J,IMINRL)=ROWS(L,J,IMINRL)
  450          QDEM(K,J,IMINRL)=QDEM(L,J,IMINRL)
  460       CONTINUE
            WORDEM(K,IMINRL)=WORDEM(L,IMINRL)
            IF (I.EQ.1) GO TO 480
            IF (I.EQ.2) GO TO 470
            WORSUP(K,IMINRL)=WORSUP(L,IMINRL)
            WORSCP(K,IMINRL)=WORSCP(L,IMINRL)
  470       WSSUM(K,IMINRL)=WSSUM(L,IMINRL)
            PRICE(1,K,IMINRL)=PRICE(1,L,IMINRL)
            PRICE(2,K,IMINRL)=PRICE(2,L,IMINRL)
  480    CONTINUE
         DO 490 J=1,4
         DO 490 I=1,ICNTRY
            EXPARM(2,J,I)=EXPARM(1,J,I)
            IF (J.GE.3) GO TO 490
            EXPARM(1,J,I)=EXPARM(2,J,I)*CHANGE(J,I)
  490    CONTINUE
         PRICE(2,1,IMINRL)=PRICE(2,1,IMINRL)*PRCHA(IMINRL)
  500 CONTINUE
C**********************************************************************
C                                                                     *
C   CONVERT TO CURRENT DOLLARS AS SET BY WPI.                         *
C   PROGRAM PRESENTLY USING 1979 DOLLARS.                             *
C   TO CHANGE MODIFY VARIABLE, WPI, IN DATA BLOCK.                    *
C                                                                     *
C NOTE: ALL CALCULATIONS ARE DONE IN TERMS OF 1970 DOLLARS.           *
C                                                                     *
C**********************************************************************
      DO 510 I=1,IWORLD
      DO 510 J=1,IYRSIM
         OUTPUT(4,I,J)=OUTPUT(4,I,J)*WPI
  510 CONTINUE
C**********************************************************************
C                                                                     *
C   WHEN DONE ITERATING PRINT AND PLOT ACCORDING TO OPTIONS           *
C                                                                     *
C**********************************************************************
      IF (IPRTCT.EQ.1) GO TO 530
      CALL CRTPRT (IMINRL,IGROW,ISHIFT)
      IF (IPLOT.EQ.0.AND.IPRTCT.NE.0) GO TO 530
      IF (IPRTCT.EQ.0) GO TO 560
      IF (IPLTPR.EQ.1) CALL PLOT (IMINRL,4,IYRSIM,IYRPLT,0,IWORLD)
      DO 520 I=1,3
      DO 520 J=1,IWORLD
         IF (IPLTVR(I,J).EQ.1) CALL PLOT (IMINRL,I,IYRSIM,IYRPLT,0,J)
  520 CONTINUE
      IF (IPRTCT.EQ.0) GO TO 560
  530 CONTINUE
```

```
      CALL LINPRT (IMINRL,IGROW,ISHIFT)
      IF (IPLOT.EQ.0) GO TO 560
      IF (IPLTPR.EQ.1) CALL PLOT (IMINRL,4,IYRSIM,IYRPLT,1,IWORLD)
      DO 540 I=1,3
      DO 540 J=1,IWORLD
         IF (IPLTVR(I,J).EQ.1) CALL PLOT (IMINRL,I,IYRSIM,IYRPLT,1,J)
  540 CONTINUE
      GO TO 560
  550 CONTINUE
C**********************************************************************
C                                                                     *
C     COME HERE IF ERROR ON INPUT OF USER OPTIONS                     *
C                                                                     *
C**********************************************************************
      IF (IERROR(1).NE.0) WRITE (6,1120) IMINRL
      IF (IERROR(2).NE.0) WRITE (6,1130) IPRTCT
      IF (IERROR(3).NE.0) WRITE (6,1140) IMINRL
      IF (IERROR(4).NE.0) WRITE (6,1150) IGROW
      IF (IERROR(5).NE.0) WRITE (6,1160) ISHIFT
      IF (IERROR(6).NE.0) WRITE (6,1170) IEXTRA
      IF (IERROR(7).NE.0) WRITE (6,1180) IYRFST,IYRSIM
      IF (IERROR(8).NE.0) WRITE (6,1190) IPLOT
      IF (IERROR(9).NE.0) WRITE (6,1200) ICNT(IERROR(9)),ICNTRY
      IF (IERROR(10).NE.0) WRITE (6,1210) ICNT(IERROR(10)),
     1  IGRT(IERROR(10))
      IF (IERROR(11).NE.0) WRITE (6,1220) IGRT(IERROR(11))
      IF (IERROR(12).NE.0) WRITE (6,1230) IERROR(12),IYR,IYRMAX
  560 CONTINUE
      STOP
 1000 FORMAT (2I1,5I2,I1)
 1010 FORMAT (I1,I2)
 1020 FORMAT (2I1,2PF14.6)
 1030 FORMAT (I1,I2,2(0PF10.4,2PF10.4,4A4))
 1040 FORMAT (2I2,I1,I2,2PF10.4)
 1050 FORMAT (1H1,20X,19H LIST OF DATA CARDS)
 1060 FORMAT (4X,37H RULE  1234567810_234567820_234567830_234567840_2345
     167850_234567860_234567870_234567880)
 1070 FORMAT (11X,I1,I2)
 1080 FORMAT (11X,2I1,5I2,I1)
 1090 FORMAT (11X,2I1,2PF14.6)
 1100 FORMAT (11X,I1,I2,2(0PF10.4,2PF10.4,4A4))
 1110 FORMAT (11X,2I2,I1,I2,2PF10.4)
 1120 FORMAT (2X,15H ERROR--IMINRL=,I2,29H ALLOWABLE VALUES MIN=1 MAX=5)
 1130 FORMAT (2X,15H ERROR--IPRTCT=,I2,29H ALLOWABLE VALUES MIN=1 MAX=3)
 1140 FORMAT (2X,15H ERROR--IYRSIM=,I2,30H ALLOWABLE VALUES MIN=1 MAX=99
     1)
 1150 FORMAT (2X,15H ERROR--IGROW =,I2,30H ALLOWABLE VALUES MIN=1 MAX=99
     1)
 1160 FORMAT (2X,15H ERROR--ISHIFT=,I2,30H ALLOWABLE VALUES MIN=1 MAX=99
     1)
 1170 FORMAT (2X,15H ERROR--IEXTRA=,I2,29H ALLOWABLE VALUES MIN=1 MAX=3)
 1180 FORMAT (2X,27H ERROR--INITIAL YEAR INDEX=,I2,
     1  28H ALLOWABLE VALUES MIN=0 MAX=,I2)
 1190 FORMAT (2X,15H ERROR-- IPLOT=,I2,30H ALLOWABLE VALUES MIN=0 MAX=99
     1)
 1200 FORMAT (2X,28H ERROR--COUNTRY GROUP INDEX=,I2,
     1  28H ALLOWABLE VALUES MIN=0 MAX=,I2)
 1210 FORMAT (2X,28H ERROR--COUNTRY GROUP INDEX=,I2,
     1  17H SPECIFYING WORLD,/10X,22HBUT GROWTH RATE INDEX=,I2,
     2  30H WHICH DOES NOT SPECIFY PRICE.)
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```
1220  FORMAT (2X,26H ERROR--GROWTH RATE INDEX=,I2,29H ALLOWABLE VALUES M MAIN384
     1IN=1 MAX=5)                                                       MAIN385
1230  FORMAT (2X,43H ERROR--INITIAL YEAR INDEX FOR GROWTH RATE=,I2,/,      MAIN386
     1  22H ALLOWABLE VALUES MIN=,I2,5H MAX=,I2)                        MAIN387
      END                                                               MAIN388
C***********************************************************************
C                                                                      *
C     CRT PRINT SUBROUTINE ----CALLED BY MAIN PROGRAM                  *
C                                                                      *
C***********************************************************************
      SUBROUTINE CRTPRT(IMINRL,IGROW,ISHIFT)                             CRT001
      COMMON / AREANM / NAME (2,4), NAMSUB (2,4), NAMCNT (4,11),         CRT002
     1  NAMEXT(2,5),NAMVAR(2,4), IYRSFT(20), SHIFT(20), ICTSHT(20),      CRT003
     2  IVETLB(22,4),ISTAR,IBLANK,IHATCH,IBAR,IPLTVR(3,12),IPLTPR        CRT004
      COMMON / AREOUT / OUTPUT (4,11,25), DOTVAR (4,10), PRDOT (4),      CRT005
     1 ICNT(25), IGRT(25), USRGRT(25), GROW(25)                          CRT006
      COMMON / AREPRM / ICNTRY,IYR,IPRICE,IQDEM,IQSUP,IQSCP,IYRSIM,      CRT007
     1 IYRFST, NIKCHK,  IWORLD, IANN, IEXCHK, INEW(3), IERROR(14),IPG,   CRT008
     2 ISVAR(20), ISLEN(20), KVAR(3), IEXTRA, CNEW(3,4), ISCALE(30)      CRT009
C***********************************************************************
C                                                                      *
C WRITE HEADER AND EXOGENOUS DATA                                      *
C                                                                      *
C***********************************************************************
      WRITE (6,5310)                                                     CRT010
      WRITE (6,5300)                                                     CRT011
      WRITE (6,5070) NAME(1,IMINRL),NAME(2,IMINRL)                       CRT012
      WRITE (6,5300)                                                     CRT013
      IF (NIKCHK.EQ.1) WRITE (6,5350)                                    CRT014
      IF (NIKCHK.EQ.1) WRITE (6,5300)                                    CRT015
      WRITE (6,5080)                                                     CRT016
      WRITE (6,5300)                                                     CRT017
      WRITE (6,5090)                                                     CRT018
      WRITE (6,5100)                                                     CRT019
      WRITE (6,5110)                                                     CRT020
      WRITE (6,5120)                                                     CRT021
      WRITE (6,5130)                                                     CRT022
      DO 5010 I=1,ICNTRY                                                 CRT023
         WRITE (6,5140) (NAMCNT(J,I),J=1,4),DOTVAR(1,I),DOTVAR(2,I),     CRT024
     1      DOTVAR(4,I),DOTVAR(3,I)                                      CRT025
 5010 CONTINUE                                                           CRT026
      WRITE (6,5300)                                                     CRT027
      WRITE (6,5150) NAMSUB(1,IMINRL),NAMSUB(2,IMINRL)                   CRT028
      WRITE (6,5300)                                                     CRT029
      WRITE (6,5160) PRDOT(IMINRL)                                       CRT030
      IF (IGROW.EQ.0) GO TO 5030                                         CRT031
C***********************************************************************
C                                                                      *
C     WRITE ALTERED GROWTH RATES HERE.                                 *
C                                                                      *
C***********************************************************************
      WRITE (6,5300)                                                     CRT032
      WRITE (6,5210)                                                     CRT033
      WRITE (6,5300)                                                     CRT034
      WRITE (6,5220)                                                     CRT035
      WRITE (6,5230)                                                     CRT036
      DO 5020 I=1,IGROW                                                  CRT037
         K=ICNT(I)                                                       CRT038
         L=IGRT(I)                                                       CRT039
         IF (K.EQ.0) K=IWORLD                                            CRT040
         IF (L.EQ.4) USRGRT(I)=USRGRT(I)/100.0                          CRT041
         WRITE (6,5240) (NAMCNT(J,K),J=1,4),(NAMEXT(M,L),M=1,2),        CRT042
     1      USRGRT(I)                                                   CRT043
 5020 CONTINUE                                                          CRT044
 5030 CONTINUE                                                          CRT045
      IF (ISHIFT.EQ.0) GO TO 5050                                       CRT046
C*********************************************************************
C                                                                    *
C     WRITE EXOGENEOUS SHIFTS HERE                                   *
C                                                                    *
C*********************************************************************
      WRITE (6,5300)                                                    CRT047
      WRITE (6,5250)                                                    CRT048
      WRITE (6,5300)                                                    CRT049
      WRITE (6,5260)                                                    CRT050
      WRITE (6,5270)                                                    CRT051
      WRITE (6,5280)                                                    CRT052
      DO 5040 I=1,ISHIFT                                                CRT053
         IYRSTP=IYRSFT(I)+ISLEN(I)                                      CRT054
         K=ISVAR(I)                                                     CRT055
         IF (K.EQ.0) K=4                                                CRT056
         L=ICTSHT(I)                                                    CRT057
         WRITE (6,5290) (NAMCNT(J,L),J=1,4),(NAMVAR(M,K),M=1,2),        CRT058
     1      SHIFT(I),IYRSFT(I),IYRSTP                                   CRT059
 5040 CONTINUE                                                          CRT060
 5050 CONTINUE                                                          CRT061
C*********************************************************************
C                                                                    *
C     WRITE WORLD VARIABLES HERE                                     *
C                                                                    *
C*********************************************************************
      DO 5060 I=1,IWORLD                                                CRT063
         WRITE (6,5300)                                                 CRT064
         WRITE (6,5300)                                                 CRT065
         WRITE (6,5170) (NAMCNT(J,I),J=1,4)                             CRT066
         IF (IMINRL.LE.2.OR.I.EQ.IWORLD) WRITE (6,5180)                 CRT067
         IF (IMINRL.LE.2.OR.I.EQ.IWORLD) WRITE (6,5190)                 CRT068
         IF (IMINRL.GE.3.AND.I.NE.IWORLD) WRITE (6,5320)                CRT069
         IF (IMINRL.GE.3.AND.I.NE.IWORLD) WRITE (6,5330)                CRT070
      DO 5060 K=IYRFST,IYRSIM                                           CRT071
         IYEAR=IANN+K                                                   CRT072
         IF (IMINRL.LE.2.OR.I.EQ.IWORLD) WRITE (6,5200) IYEAR,(OUTPUT(J, CRT073
     1      I,K),J=1,4)                                                 CRT074
         IF (IMINRL.GE.3.AND.I.NE.IWORLD) WRITE (6,5340) IYEAR,OUTPUT(1, CRT075
     1      I,K),OUTPUT(3,I,K),OUTPUT(4,I,K)                            CRT076
 5060 CONTINUE                                                          CRT077
      RETURN                                                            CRT078

 5070 FORMAT (26X,2A4)                                                  CRT079
 5080 FORMAT (27X,11HASSUMPTIONS)                                       CRT080
 5090 FORMAT (25X,15HRATES OF CHANGE)                                   CRT081
 5100 FORMAT (40X,5HMONEY)                                              CRT082
 5110 FORMAT (27X,30HINTEREST    GROWTH      CAPITAL)                   CRT083
 5120 FORMAT (18X,41HINCOME      RATE        RATE    ACQUISITION)       CRT084
 5130 FORMAT (17X,42H--------  --------   --------  -----------)        CRT085
 5140 FORMAT (1X,4A4,1X,2PF6.2,4X,F6.2,4X,0PF6.2,6X,2PF6.2)             CRT086
 5150 FORMAT (17X,20HSUBSTITUTE METAL -- ,2A4)                          CRT087
 5160 FORMAT (17X,23HRATE OF PRICE CHANGE   ,2PF6.2)                    CRT088
 5170 FORMAT (24X,4A4)                                                  CRT089
 5180 FORMAT (1H ,8X,44HYEAR     SUPPLY      SCRAP     DEMAND      PRICE)  CRT090
 5190 FORMAT (9X,44H----     ------     -----     ------      -----)        CRT091
 5200 FORMAT (9X,I4,3(2X,F8.1),2X,F8.3)                                     CRT092
 5210 FORMAT (1H0,9X,45HTHE FOLLOWING GROWTH RATES HAVE BEEN ALTERED.)      CRT093
 5220 FORMAT (15X,35HCOUNTRY GROUP          VARIABLE  RATE)                 CRT094
 5230 FORMAT (15X,35H-------------          --------  ----)                 CRT095
 5240 FORMAT (14X,4A4,6X,2A4,1X,2PF5.1)                                     CRT096
 5250 FORMAT (1H0,4X,52HTHE FOLLOWING EXTERNAL SHOCK EFFECTS HAVE BEEN U    CRT097
     1SED.)                                                                 CRT098
 5260 FORMAT (32X,37HPERCENTAGE                INITIAL  FINAL)              CRT099
 5270 FORMAT (5X,53HCOUNTRY GROUP    EQUATION     SHIFT       YEAR    YEA   CRT100
     1R)                                                                    CRT101
 5280 FORMAT (5X,53H-------------    --------     -----       ----    ---   CRT102
     1-)                                                                    CRT103
 5290 FORMAT (4X,4A4,2X,2A4,2X,2PF8.2,7X,I2,6X,I2)                          CRT104
 5300 FORMAT (1H )                                                          CRT105
 5310 FORMAT (1H1)                                                          CRT106
 5320 FORMAT (1H-,13X,35HYEAR     SUPPLY      DEMAND      PRICE)            CRT107
 5330 FORMAT (14X,35H----     ------      ------      -----)                CRT108
 5340 FORMAT (14X,I4,2X,F8.1,3X,F8.1,2X,F8.3)                               CRT109
 5350 FORMAT (26X,13HMODIFIED CASE)                                         CRT110
      END                                                                   CRT111
C***********************************************************************
C                                                                      *
C     LINE PRINTER PRINT SUBROUTINE ----CALLED BY MAIN PROGRAM         *
C                                                                      *
C***********************************************************************
      SUBROUTINE LINPRT(IMINRL,IGROW,ISHIFT)                                LPRT001
      COMMON / AREANM / NAME (2,4), NAMSUB (2,4), NAMCNT (4,11),            LPRT002
     1  NAMEXT(2,5),NAMVAR(2,4), IYRSFT(20), SHIFT(20), ICTSHT(20),         LPRT003
     2  IVETLB(22,4),ISTAR,IBLANK,IHATCH,IBAR,IPLTVR(3,12),IPLTPR           LPRT004
      COMMON / AREOUT / OUTPUT (4,11,25), DOTVAR (4,10), PRDOT (4),         LPRT005
     1 ICNT(25), IGRT(25), USRGRT(25), GROW(25)                             LPRT006
      COMMON / AREPRM / ICNTRY,IYR,IPRICE,IQDEM,IQSUP,IQSCP,IYRSIM,         LPRT007
     1 IYRFST, NIKCHK,  IWORLD, IANN, IEXCHK, INEW(3), IERROR(14),IPG,      LPRT008
     2 ISVAR(20), ISLEN(20), KVAR(3), IEXTRA, CNEW(3,4), ISCALE(30)         LPRT009
C***********************************************************************
C                                                                      *
C     WRITE HEADER INFO AND EXOGENEOUS DATA                            *
C                                                                      *
C***********************************************************************
      IPRNT=ICNTRY-1                                                        LPRT010
      WRITE (6,5380)                                                        LPRT011
      WRITE (6,5370)                                                        LPRT012
      WRITE (6,5140) NAME(1,IMINRL),NAME(2,IMINRL)                          LPRT013
      WRITE (6,5370)                                                        LPRT014
      IF (NIKCHK.EQ.1) WRITE (6,5420)                                       LPRT015
      IF (NIKCHK.EQ.1) WRITE (6,5370)                                       LPRT016
      WRITE (6,5150)                                                        LPRT017
      WRITE (6,5370)                                                        LPRT018
      WRITE (6,5160)                                                        LPRT019
      WRITE (6,5170)                                                        LPRT020
      WRITE (6,5180)                                                        LPRT021
      WRITE (6,5190)                                                        LPRT022
      WRITE (6,5200)                                                        LPRT023
      DO 5010 I=1,ICNTRY                                                    LPRT024
         WRITE (6,5210) (NAMCNT(J,I),J=1,4),DOTVAR(1,I),DOTVAR(2,I),        LPRT025
     1      DOTVAR(4,I),DOTVAR(3,I)                                         LPRT026
 5010 CONTINUE                                                              LPRT027
      WRITE (6,5370)                                                        LPRT028
      WRITE (6,5220) NAMSUB(1,IMINRL),NAMSUB(2,IMINRL)                      LPRT029
      WRITE (6,5370)
      WRITE (6,5230) PRDOT(IMINRL)
      IF (IGROW.EQ.0) GO TO 5030
C***********************************************************************
C                                                                      *
C     WRITE ALTERED GROWTH RATES                                       *
C                                                                      *
C***********************************************************************
      WRITE (6,5370)
      WRITE (6,5280)
      WRITE (6,5370)
      WRITE (6,5290)
      WRITE (6,5300)
      DO 5020 I=1,IGROW
         K=ICNT(I)
         L=IGRT(I)
         IF (K.EQ.0) K=IWORLD
         IF (L.EQ.4) USRGRT(I)=USRGRT(I)/100.0
         WRITE (6,5310) (NAMCNT(J,K),J=1,4),(NAMEXT(M,L),M=1,2),
     1      USRGRT(I)
 5020 CONTINUE
 5030 CONTINUE
      IF (ISHIFT.EQ.0) GO TO 5050
C***********************************************************************
C                                                                      *
C     WRITE EXOGENEOUS SHIFTS                                          *
C                                                                      *
C***********************************************************************
      WRITE (6,5370)
      WRITE (6,5320)
      WRITE (6,5370)
      WRITE (6,5330)
      WRITE (6,5340)
      WRITE (6,5350)
      DO 5040 I=1,ISHIFT
         IYRSTP=IYRSFT(I)+ISLEN(I)
         K=ISVAR(I)
         IF (K.EQ.0) K=4
         L=ICTSHT(I)
         WRITE (6,5360) (NAMCNT(J,L),J=1,4),(NAMVAR(M,K),M=1,2),
     1      SHIFT(I),IYRSFT(I),IYRSTP
 5040 CONTINUE
 5050 CONTINUE
      IF (IEXTRA.EQ.0) GO TO 5090
C***********************************************************************
C                                                                      *
C     IF EXTRA COUNTRY, WRITE INDIVIDUAL COUNTRY DATA                  *
C                                                                      *
C***********************************************************************
      L=ICNTRY/2
      LL=ICNTRY-(L*2)
      DO 5080 K=1,L
         KK=((K-1)*2)+1
         LLL=MOD(K,2)
         IF (LLL.EQ.1) WRITE (6,5380)
         WRITE (6,5370)
         WRITE (6,5430) (NAMCNT(J,KK),J=1,4),(NAMCNT(J,KK+1),J=1,4)
         IF (IMINRL.LE.2) WRITE (6,5440)
         IF (IMINRL.LE.2) WRITE (6,5450)
         IF (IMINRL.GE.3) WRITE (6,5470)
         IF (IMINRL.GE.3) WRITE (6,5480)                                LPRT075
         DO 5060 M=IYRFST,IYRSIM                                        LPRT076
            IYEAR=IANN+M                                                LPRT077
            IF (IMINRL.LE.2) WRITE (6,5460) IYEAR,(OUTPUT(J,KK,M),J=1,  LPRT078
     1        4),IYEAR,(OUTPUT(J,KK+1,M),J=1,4)                         LPRT079
            IF (IMINRL.GE.3) WRITE (6,5490) IYEAR,OUTPUT(1,KK,M),OUTPUT LPRT080
     1        (3,KK,M),OUTPUT(4,KK,M),IYEAR,OUTPUT(1,KK+1,M),           LPRT081
     1        OUTPUT(3,KK+1,M),OUTPUT(4,KK+1,M)                         LPRT082
 5060    CONTINUE                                                       LPRT083
         IF ((K.NE.L).OR.(LL.EQ.0)) GO TO 5080                          LPRT084
         WRITE (6,5370)                                                 LPRT085
         WRITE (6,5240) (NAMCNT(J,ICNTRY),J=1,4)                        LPRT086
         WRITE (6,5370)                                                 LPRT087
         IF (IMINRL.LE.2) WRITE (6,5250)                                LPRT088
         IF (IMINRL.LE.2) WRITE (6,5260)                                LPRT089
         IF (IMINRL.GE.3) WRITE (6,5390)                                LPRT090
         IF (IMINRL.GE.3) WRITE (6,5400)                                LPRT091
         DO 5070 M=IYRFST,IYRSIM                                        LPRT092
            IYEAR=IANN+M                                                LPRT093
            IF (IMINRL.LE.2) WRITE (6,5270) IYEAR,(OUTPUT(J,ICNTRY,M),  LPRT094
     1        J=1,4)                                                    LPRT095
            IF (IMINRL.GE.2) WRITE (6,5410) IYEAR,(OUTPUT(J,ICNTRY,M),  LPRT096
     1        J=1,4)                                                    LPRT097
 5070    CONTINUE                                                       LPRT098
 5080 CONTINUE                                                          LPRT099
      GO TO 5120                                                        LPRT100
 5090 CONTINUE                                                          LPRT101
C***********************************************************************
C                                                                      *
C     IF NO EXTRA COUNTRIES, WRITE INDIVIDUAL COUNTRY DATA             *
C                                                                      *
C***********************************************************************
      IF (IPG.GT.10) WRITE (6,5380)                                     LPRT102
      WRITE (6,5500)                                                    LPRT103
      WRITE (6,5510)                                                    LPRT104
      WRITE (6,5520)                                                    LPRT105
      DO 5100 K=IYRFST,IYRSIM                                           LPRT106
         IYEAR=IANN+K                                                   LPRT107
         WRITE (6,5530) IYEAR,(OUTPUT(1,J,K),OUTPUT(3,J,K),J=1,ICNTRY)  LPRT108
 5100 CONTINUE                                                          LPRT109
      IF (IMINRL.GE.3) GO TO 5120                                       LPRT110
      IF (IPG.NE.0.AND.IPG.LE.10) WRITE (6,5380)                        LPRT111
      WRITE (6,5560)                                                    LPRT112
      WRITE (6,5590)                                                    LPRT113
      WRITE (6,5600)                                                    LPRT114
      WRITE (6,5610)                                                    LPRT115
      DO 5110 K=IYRFST,IYRSIM                                           LPRT116
         IYEAR=IANN+K                                                   LPRT117
         WRITE (6,5620) IYEAR,(OUTPUT(2,J,K),J=1,IPRNT)                 LPRT118
 5110 CONTINUE                                                          LPRT119
 5120 CONTINUE                                                          LPRT120
C***********************************************************************
C                                                                      *
C     WRITE WORLD DATA HERE                                            *
C                                                                      *
C***********************************************************************
      IF ((IPG.EQ.0.AND.IMINRL.LE.2).OR.(IEXTRA.NE.0)) WRITE (6,5380)   LPRT121
      WRITE (6,5540)                                                    LPRT122
      WRITE (6,5550)                                                    LPRT123
      WRITE (6,5560)                                                    LPRT124
      DO 5130 K=IYRFST,IYRSIM
         IYEAR=IANN+K
         WRITE (6,5570) IYEAR,(OUTPUT(J,IWORLD,K),J=1,4)
 5130 CONTINUE
      RETURN

 5140 FORMAT (60X,2A4)
 5150 FORMAT (59X,11HASSUMPTIONS)
 5160 FORMAT (57X,15HRATES OF CHANGE)
 5170 FORMAT (72X,5HMONEY)
 5180 FORMAT (59X,30HINTEREST    GROWTH      CAPITAL)
 5190 FORMAT (50X,41HINCOME      RATE        RATE    ACQUISITION)
 5200 FORMAT (1H+,48X,42H________  --------  --------  -----------)
 5210 FORMAT (33X,4A4,1X,2PF6.2,4X,F6.2,4X,0PF6.2,6X,2PF6.2)
 5220 FORMAT (49X,20HSUBSTITUTE METAL -- ,2A4)
 5230 FORMAT (49X,23HRATE OF PRICE CHANGE   ,2PF6.2)
 5240 FORMAT (57X,4A4)
 5250 FORMAT (1H-,42X,44HYEAR     SUPPLY      SCRAP    DEMAND      PRICE)
 5260 FORMAT (43X,44H____     ------      -----    ------      -----)
 5270 FORMAT (43X,I4,3(2X,F8.1),2X,F8.3)
 5280 FORMAT (1H0,41X,45HTHE FOLLOWING GROWTH RATES HAVE BEEN ALTERED.)
 5290 FORMAT (47X,35HCOUNTRY GROUP            VARIABLE  RATE)
 5300 FORMAT (1H+,46X,35H_____________            --------  ----)
 5310 FORMAT (46X,4A4,6X,2A4,1X,2PF5.1)
 5320 FORMAT (1H0,36X,52HTHE FOLLOWING EXTERNAL SHOCK EFFECTS HAVE BEEN
     1USED.)
 5330 FORMAT (53X,37HPERCENTAGE              INITIAL  FINAL)
 5340 FORMAT (37X,53HCOUNTRY GROUP     EQUATION      SHIFT       YEAR    YE
     1AR)
 5350 FORMAT (1H+,36X,53H_____________     --------      -----       ----
     1  ----)
 5360 FORMAT (36X,4A4,2X,2A4,2X,2PF8.2,7X,I2,6X,I2)
 5370 FORMAT (1H )
 5380 FORMAT (1H1,////)
 5390 FORMAT (1H-,38X,35HYEAR     SUPPLY      DEMAND      PRICE)
 5400 FORMAT (39X,35H____     ------      ------      -----)
 5410 FORMAT (43X,I4,2X,F8.1,3X,F8.1,2X,F8.3)
 5420 FORMAT (1H0,50X,13HMODIFIED CASE)
 5430 FORMAT (10X,2(24X,4A4,13X))
 5440 FORMAT (1H0,10X,2(8X,44HYEAR     SUPPLY      SCRAP    DEMAND      PRI
     1CE))
 5450 FORMAT (1H+,10X,2(8X,44H____     ------      -----    ------      ---
     1__))
 5460 FORMAT (1X,10X,2(8X,I4,3(2X,F8.1),2X,F8.3))
 5470 FORMAT (1H-,5X,2(18X,35HYEAR     SUPPLY      DEMAND      PRICE))
 5480 FORMAT (6X,2(18X,35H____     ------      ------      -----))
 5490 FORMAT (6X,2(18X,I4,2X,F8.1,3X,F8.1,2X,F8.3))
 5500 FORMAT (1H0,7X,122HNORTH AMERICA       SOUTH AMERICA           ASIA
     1             AFRICA              EUROPE            OCEANIA      CENTRALL
     2Y PLANNED)
 5510 FORMAT (7H YEAR  ,7(16HSUPPLY  DEMAND      ))
 5520 FORMAT (7H+____  ,7(16H______  ------      ))
 5530 FORMAT (1X,I4,1X,7(F7.1,1X,F7.1,3X))
 5540 FORMAT (1H0,62X,5HWORLD,/)
 5550 FORMAT (44X,47HYEAR  PRODUCTION     SCRAP   CONSUMPTION  PRICE)
 5560 FORMAT (1H+,43X,47H____  -----------     -----   -----------    -----
     1)
 5570 FORMAT (44X,I4,3X,F8.1,4X,F7.1,3X,F8.1,3X,F7.3)
 5580 FORMAT (///,55X,20HSECONDARY PRODUCTION,/)
 5590 FORMAT (40X,5HNORTH,4X,5HSOUTH,42X,9HCENTRALLY)
 5600 FORMAT (31X,73HYEAR    AMERICA  AMERICA    ASIA    AFRICA    EUROP LPRT184
     1E    OCEANIA    PLANNED)                                           LPRT185
 5610 FORMAT (1H+,30X,73H____    _______  _______    ____    ______    _ LPRT186
     1_____    _______    _______)                                       LPRT187
 5620 FORMAT (31X,I4,3X,F7.1,3(2X,F7.1),2X,2(2X,F7.1),7X,3HN/A)          LPRT188
      END                                                                LPRT189
C*********************************************************************
C                                                                    *
C      SUBROUTINE PLOT                                               *
C  CALLED BY MAIN PROGRAM                                            *
C                                                                    *
C*********************************************************************
      SUBROUTINE PLOT(IMINRL,IVAR,N,IYRST,IPLT,ICTYPL)                   PLOT001
      COMMON / AREOUT / OUTPUT (4,11,25), DOTVAR (4,10), PROOT (4),      PLOT002
     1 ICNT(25), IGRT(25), USRGRT(25), GROW(25)                          PLOT003
      COMMON / AREPRM / ICNTRY,IYR,IPRICE,IQDEM,IQSUP,IQSCP,IYRSIM,      PLOT004
     1 IYRFST, NIKCHK,  IWORLD, IANN, IEXCHK, INEW(3), IERROR(14),IPG,   PLOT005
     2 ISVAR(20), ISLEN(20), KVAR(3), IEXTRA, CNEW(3,4), ISCALE(30)      PLOT006
      COMMON / AREANM / NAME (2,4), NAMSUB (2,4), NAMCNT (4,11),         PLOT007
     1  NAMEXT(2,5),NAMVAR(2,4), IYRSFT(20), SHIFT(20), ICTSHT(20),      PLOT008
     2  IVETLB(22,4),ISTAR,IBLANK,IHATCH,IBAR,IPLTVR(3,12),IPLTPR        PLOT009
      DIMENSION IOUT(60,42),VLAB(26),IYROUT(20)                          PLOT010
      DO 5010 I=1,42                                                     PLOT011
      DO 5010 J=1,60                                                     PLOT012
         IOUT(J,I)=IBLANK                                                PLOT013
 5010 CONTINUE                                                           PLOT014
      ILEN=60                                                            PLOT015
      IF (IPLT.EQ.1) GO TO 5020                                          PLOT016
      IHGT=20                                                            PLOT017
      HGHT=20.0                                                          PLOT018
      GO TO 5030                                                         PLOT019
 5020 CONTINUE                                                           PLOT020
      IHGT=40                                                            PLOT021
      HGHT=40.0                                                          PLOT022
 5030 CONTINUE                                                           PLOT023
      IPITER=IHGT+2                                                      PLOT024
      IVAXIS=IPITER-1                                                    PLOT025
      DO 5040 J=1,60                                                     PLOT026
         IOUT(J,IVAXIS)=IBAR                                             PLOT027
 5040 CONTINUE                                                           PLOT028
      IHTICK=4                                                           PLOT029
      IHINC=1                                                            PLOT030
      IHINC2=4                                                           PLOT031
      IF (N.GE.17.AND.N.LE.20) IHTICK=3                                  PLOT032
      IF (21.LE.N) IHINC=2                                               PLOT033
      IF (N.GE.17.AND.N.LE.20) IHINC2=3                                  PLOT034
      IF (21.LE.N.AND.N.LE.40) IHINC2=2                                  PLOT035
      IF (41.LE.N) IHINC2=1                                              PLOT036
      K=(ILEN/IHTICK)                                                    PLOT037
      IX=IYRST                                                           PLOT038
      DO 5050 I=1,K                                                      PLOT039
         J=((I-1)*IHTICK)+1                                              PLOT040
         IOUT(J,IPITER)=IHATCH                                           PLOT041
         IYROUT(I)=MOD(IX,100)                                           PLOT042
         IX=IX+IHINC                                                     PLOT043
 5050 CONTINUE                                                           PLOT044
      CALL SCALE (IMINRL,IVAR,N,HGHT,ILEN,RMIN,RMAX,RINC,ICTYPL)         PLOT045
      IF (RINC.LE.0.0001) GO TO 5110                                     PLOT046
      DO 5060 I=1,N                                                      PLOT047
         J=((I-1)*IHINC2)+1                                              PLOT048
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          IOUT(J,ISCALE(I))=ISTAR                                       PLOT049
 5060 CONTINUE                                                          PLOT050
      KK=(IHGT/2)+1                                                     PLOT051
      X=0.0                                                             PLOT052
      DO 5070 I=1,KK                                                    PLOT053
         VLAB(I)=RMAX-(2*X)                                             PLOT054
         X=X+RINC                                                       PLOT055
 5070 CONTINUE                                                          PLOT056
      IF (IPLT.NE.1) GO TO 5090                                         PLOT057
      WRITE (6,5120) (NAMCNT(I,ICTYPL),I=1,4)                           PLOT058
      WRITE (6,5140) (IVETLB(I,IVAR),I=1,6)                             PLOT059
      WRITE (6,5290)                                                    PLOT060
      DO 5080 I=1,IVAXIS                                                PLOT061
         KK=MOD(I,2)                                                    PLOT062
         LL=(I/2)+1                                                     PLOT063
         IF (KK.NE.0.AND.IVAR.EQ.4) WRITE (6,5160) VLAB(LL),(IOUT(J,I), PLOT064
     1     J=1,ILEN)                                                    PLOT065
         IF (KK.NE.0.AND.IVAR.NE.4) WRITE (6,5180) VLAB(LL),(IOUT(J,I), PLOT066
     1     J=1,ILEN)                                                    PLOT067
         IF (KK.EQ.0) WRITE (6,5200) (IOUT(J,I),J=1,ILEN)               PLOT068
 5080 CONTINUE                                                          PLOT069
      WRITE (6,5260) (IOUT(J,IPITER),J=1,ILEN)                          PLOT070
      IF (IHTICK.EQ.4) WRITE (6,5220) (IYROUT(J),J=1,K)                 PLOT071
      IF (IHTICK.EQ.3) WRITE (6,5240) (IYROUT(I),I=1,K)                 PLOT072
      WRITE (6,5280)                                                    PLOT073
      WRITE (6,5270) (NAME(I,IMINRL),I=1,2)                             PLOT074
      GO TO 5110                                                        PLOT075
 5090 CONTINUE                                                          PLOT076
      WRITE (6,5130) (NAMCNT(I,ICTYPL),I=1,4)                           PLOT077
      DO 5100 I=1,IVAXIS                                                PLOT078
         KK=MOD(I,2)                                                    PLOT079
         LL=(I/2)+1                                                     PLOT080
         IF (KK.NE.0.AND.IVAR.EQ.4) WRITE (6,5150) IVETLB(I,IVAR),      PLOT081
     1     VLAB(LL),(IOUT(J,I),J=1,ILEN)                                PLOT082
         IF (KK.NE.0.AND.IVAR.NE.4) WRITE (6,5170) IVETLB(I,IVAR),      PLOT083
     1     VLAB(LL),(IOUT(J,I),J=1,ILEN)                                PLOT084
         IF (KK.EQ.0) WRITE (6,5190) IVETLB(I,IVAR),(IOUT(J,I),J=1,ILEN) PLOT085
 5100 CONTINUE                                                          PLOT086
      WRITE (6,5250) (IOUT(J,IPITER),J=1,ILEN)                          PLOT087
      IF (IHTICK.EQ.4) WRITE (6,5210) (IYROUT(J),J=1,K)                 PLOT088
      IF (IHTICK.EQ.3) WRITE (6,5230) (IYROUT(I),I=1,K)                 PLOT089
 5110 CONTINUE                                                          PLOT090
      RETURN                                                            PLOT091

 5120 FORMAT (1H1,///,51X,4A4)                                          PLOT092
 5130 FORMAT (1H1,31X,4A4)                                              PLOT093
 5140 FORMAT (1H0,56X,6A1)                                              PLOT094
 5150 FORMAT (6X,A1,1X,F8.2,1X,2H-I,60A1)                               PLOT095
 5160 FORMAT (28X,F8.2,1X,2H-I,60A1)                                    PLOT096
 5170 FORMAT (6X,A1,1X,F8.1,1X,2H-I,60A1)                               PLOT097
 5180 FORMAT (28X,F8.1,1X,2H-I,60A1)                                    PLOT098
 5190 FORMAT (6X,A1,11X,1HI,60A1)                                       PLOT099
 5200 FORMAT (38X,1HI,60A1)                                             PLOT100
 5210 FORMAT (18X,16(I2,2X))                                            PLOT101
 5220 FORMAT (38X,16(I2,2X))                                            PLOT102
 5230 FORMAT (18X,21(I2,1X))                                            PLOT103
 5240 FORMAT (38X,21(I2,1X))                                            PLOT104
 5250 FORMAT (19X,60A1)                                                 PLOT105
 5260 FORMAT (39X,60A1)                                                 PLOT106
 5270 FORMAT (1H0,55X,2A4)                                              PLOT107
 5280 FORMAT (1H0,57X,4HYEAR)                                           PLOT108
 5290 FORMAT (1H0)                                                      PLOT109
      END                                                               PLOT110
C***********************************************************************
C                                                                      *
C     SUBROUTINE SCALE                                                 *
C                                                                      *
C  CALLED BY PLOT                                                      *
C                                                                      *
C***********************************************************************
      SUBROUTINE SCALE(IMINRL,IVAR,N,HGHT,ILEN,RMIN,RMAX,RINC,ICTYPL)   SCAL001
      COMMON / AREOUT / OUTPUT (4,11,25), DOTVAR (4,10), PRDCT (4),     SCAL002
     1 ICNT(25), IGRT(25), USRGRT(25), GROW(25)                         SCAL003
      COMMON / AREPRM / ICNTRY,IYR,IPRICE,IQDEM,IQSUP,IQSCP,IYRSIM,     SCAL004
     1 IYRFST, NIKCHK,  IWORLD, IANN, IEXCHK, INEW(3), IERROR(14),IPG,  SCAL005
     2 ISVAR(20), ISLEN(20), KVAR(3), IEXTRA, CNEW(3,4), ISCALE(30)     SCAL006
      COMMON / AREANM / NAME (2,4), NAMSUB (2,4), NAMCNT (4,11),        SCAL007
     1  NAMEXT(2,5),NAMVAR(2,4), IYRSFT(20), SHIFT(20), ICTSHT(20),     SCAL008
     2  IVETLB(22,4),ISTAR,IBLANK,IHATCH,IBAR,IPLTVR(3,12),IPLTPR       SCAL009
      RMAX=0.0                                                          SCAL010
      RMIN=100000000000.0                                               SCAL011
      DO 10 I=1,N                                                       SCAL012
         IF (OUTPUT(IVAR,ICTYPL,I).LT.RMIN) RMIN=OUTPUT(IVAR,ICTYPL,I)  SCAL013
         IF (OUTPUT(IVAR,ICTYPL,I).GT.RMAX) RMAX=OUTPUT(IVAR,ICTYPL,I)  SCAL014
   10 CONTINUE                                                          SCAL015
      MIN=IFIX(RMIN+.5)                                                 SCAL016
      MAX=IFIX(RMAX+.5)                                                 SCAL017
      RINC=(RMAX-RMIN)/HGHT                                             SCAL018
      IF (RINC.LE.0.0001) GO TO 30                                      SCAL019
      ADD=.5*RINC                                                       SCAL020
      DO 20 I=1,N                                                       SCAL021
         SCALER=((RMAX-OUTPUT(IVAR,ICTYPL,I))/RINC)                     SCAL022
         ISCALE(I)=IFIX(SCALER+.5)+1                                    SCAL023
   20 CONTINUE                                                          SCAL024
   30 CONTINUE                                                          SCAL025
      RETURN                                                            SCAL026
      END                                                               SCAL027

C************************************************************************
C                                                                       *
C     THIS FUNCTION SUBPROGRAM IS USED TO CALCULATE VALUES FOR DEMAND,  *
C SCRAP, AND SUPPLY.                                                    *
C************************************************************************

      FUNCTION GENADD(J,ICNT,IMINRL,IFUNC,ITER,X2,X3,X4,                GADD001
     1  X5,X6,X7,X8,X9,X10,X11,X12,X13,X14,X15)                         GADD002
      COMMON / AREAGN / GENSUB(15,10,4,3),GSHIFT(50,10,3)               GADD003
      DIMENSION X(15)                                                   GADD004
      X(1)=1.0                                                          GADD005
      X(2)=X2                                                           GADD006
      X(3)=X3                                                           GADD007
      X(4)=X4                                                           GADD008
      X(5)=X5                                                           GADD009
      X(6)=X6                                                           GADD010
      X(7)=X7                                                           GADD011
      X(8)=X8                                                           GADD012
      X(9)=X9                                                           GADD013
      X(10)=X10                                                         GADD014
      X(11)=X11                                                         GADD015
      X(12)=X12                                                         GADD016
      X(13)=X13                                                         GADD017
      X(14)=X14                                                         GADD018
      X(15)=X15                                                         GADD019
      GENADD=0.0                                                        GADD020
      DO 10 I=1,J                                                       GADD021
         GENADD=GENADD+(X(I)*GENSUB(I,ICNT,IMINRL,IFUNC))               GADD022
   10 CONTINUE                                                          GADD023
      GENADD=GENADD*GSHIFT(ITER,ICNT,IFUNC)                             GADD024
      RETURN                                                            GADD025
      END                                                               GADD026
C**********************************************************************
C                                                                     *
C     THIS FUNCTION SUBPROGRAM IS USED TO CALCULATE PRICE VALUES      *
C                                                                     *
C**********************************************************************
      FUNCTION PRCADD(IPRICE,IMINRL,ITER,X2,X3,X4,                      PADD001
     1  X5,X6,X7,X8,X9,X10,X11,X12,X13,X14,X15)                         PADD002
      COMMON / AREAPR / PRCSUB(15,4),PSHIFT(50),PRCHA(4)                PADD003
      DIMENSION X(15)                                                   PADD004
      X(1)=1.0                                                          PADD005
      X(2)=X2                                                           PADD006
      X(3)=X3                                                           PADD007
      X(4)=X4                                                           PADD008
      X(5)=X5                                                           PADD009
      X(6)=X6                                                           PADD010
      X(7)=X7                                                           PADD011
      X(8)=X8                                                           PADD012
      X(9)=X9                                                           PADD013
      X(10)=X10                                                         PADD014
      X(11)=X11                                                         PADD015
      X(12)=X12                                                         PADD016
      X(13)=X13                                                         PADD017
      X(14)=X14                                                         PADD018
      X(15)=X15                                                         PADD019
      PRCADD=0.0                                                        PADD020
      DO 10 I=1,IPRICE                                                  PADD021
         PRCADD=PRCADD+(X(I)*PRCSUB(I,IMINRL))                          PADD022
   10 CONTINUE                                                          PADD023
      PRCADD=PRCADD*PSHIFT(ITER)                                        PADD024
      RETURN                                                            PADD025
      END                                                               PADD026
C**********************************************************************
C                                                                     *
C                     INDEXING CONVENTIONS USED                       *
C                                                                     *
C  I. MINERALS                                                        *
C        DENOTED BY IMINRL IN DISCUSSION HENCEFORTH, AND IN PROGRAM.  *
C        MAY BE ABBREVIATED AS IMIN OR IMN.                           *
C                                                                     *
C        MINERAL              IMINRL                                  *
C         COPPER                1                                     *
C        ALUMINUM               2                                     *
C         NICKEL                3                                     *
C          ZINC                 4                                     *
C                                                                     *
C  II. COUNTRY GROUPS                                                 *
C        DENOTED BY CGROUP IN DISCUSSION.                             *
C        MAY BE ABBREVIATED AS CGRP OR CGP.                           *
```

```
C                                                                      *
C        COUNTRY             ALPHABETIC          NUMERIC               *
C         GROUP                INDEX              INDEX                *
C        NORTH AMERICA           NA               1                    *
C        SOUTH AMERICA           SA               2                    *
C        ASIA                    AS               3                    *
C        AFRICA                  AF               4                    *
C        EUROPE                  EU               5                    *
C        OCEANIA                 OC               6                    *
C        CENTRALLY PLANNED       CP               7                    *
C        EXPANSION GROUPS     XX,YY,ZZ           8,9,10                *
C                                                                      *
C  III. TIME                                                           *
C        DENOTED BY T IN DISCUSSION                                    *
C                                                                      *
C        VALUE               INDEX                                     *
C        CURRENT YEAR          1                                       *
C        LAGGED ONCE           2                                       *
C        LAGGED TWICE          3                                       *
C        LAGGED THRICE         4                                       *
C                                                                      *
C IV. EQUATION COEFFICIENTS                                            *
C                                                                      *
C        ABBREVIATED AS ICOEF                                          *
C        VALUES RUN FROM 1 TO 15                                       *
C                                                                      *
C----------------------------------------------------------------------*
C             DESCRIPTION OF MAIN ARRAYS                               *
C                                                                      *
C                                                                      *
C  I. HISTORICAL AND INSTITUTIONAL DATA                                *
C                                                                      *
C        A.  EXOGENEOUS DATA                                           *
C                                                                      *
C     ARRAY   DIMENSION           DESCRIPTION                          *
C                                                                      *
C   1. EXPARM T X I X CGROUP    INCOME AND INTEREST RATE LEVEL,        *
C             T=1,2; I=1,2,3,4; GROWTH OF MONEY AND CAPITAL STOCKS     *
C   2. DOTVAR J X CGROUP        GROWTH RATES OF INCOME, INTEREST RATE, *
C             J=1,2,3,4         CAPITAL STOCK, AND MONEY STOCK.        *
C   3. PRDOT  IMINRL            RATE OF PRICE CHANGE FOR SUBSTITUTES   *
C                                                                      *
C        B.  ENDOGENEOUS DATA                                          *
C                                                                      *
C     ARRAY   DIMENSION           DESCRIPTION                          *
C                                                                      *
C   1. PRICE  I X T X IMINRL    PRICES OF MINERALS AND SUBSTITUTES     *
C   2. QDEM   T X CGRP. X IMIN. QUANTITY DEMANDED OF EACH MINERAL      *
C   3. QSUP   T X CGRP X IMIN   QUANTITY OF PRIMARY PRODUCTION (SUPPLY)*
C   4. QSCP   T X CGRP X IMIN  QUANTITY OF SECONDARY PRODUCTION (SCRAP)*
C   5. QSPROD T X CGRP X IMIN   SUM OF PAST PRODUCTION                 *
C                                                                      *
C  II. PROGRAM PARAMETERS                                              *
C                                                                      *
C        A.   INDICES AND COUNTERS                                     *
C              SEE DESCRIPTION BELOW                                   *
C                                                                      *
C        B.   EQUATION COEFFICIENTS                                    *
C                                                                      *
C     ARRAY   DIMENSION               DESCRIPTION                      *
```

```
C
C   1. PRCOEF ICOEF X IMINRL        PRICE EQUATION                       *
C   2. DMCOEF ICOEF X CGP X IMN     DEMAND EQUATIONS                     *
C   3. SRCOEF ICOEF X CGP X IMN     SCRAP EQUATIONS                      *
C   4. SPCOEF ICOEF X CGP X IMN     SUPPLY EQUATIONS                     *
C                                                                        *
C                                                                        *
C                                                                        *
C        AN ATTEMPT HAS BEEN MADE TO EQUIVALENCE THE LARGER OF           *
C   THESE ARRAYS TO SMALLER ARRAYS WITH EASILY UNDERSTOOD MNENOMIC       *
C   NAMES.                                                               *
C                                                                        *
C------------------------------------------------------------------------*
C                                                                        *
C        EXPLANATION OF EQUIVALENCING                                    *
C                                                                        *
C I. HISTORICAL AND EXOGENEOUS DATA                                      *
C                                                                        *
C        FOR BOTH EXPARM AND DOTVAR , THE FIRST SUBSCRIPT CORRESPONDS    *
C   TO A PARTICULAR VARIABLE AS FOLLOW:                                  *
C                                                                        *
C        VARIABLE                 INDEX (I FOR EXPARM, J FOR DOTVAR)     *
C        INCOME                                 1                        *
C      INTEREST RATE                            2                        *
C   GROWTH RATE OF CAPITAL STOCK                3                        *
C   GROWTH RATE OF MONEY STOCK                  4                        *
C                                                                        *
C                                                                        *
C   A.   EXPARM                                                          *
C                                                                        *
C             EXPARM CONTAINS THE LEVEL VALUES OF INCOME AND             *
C      THE INTEREST RATE. IT ALSO CONTAINS THE GROWTH RATES OF           *
C      MONEY STOCK AND CAPITAL STOCK.                                    *
C                                                                        *
C             IT IS EQUIVALENCED TO TEN 1-DIMENSIONAL ARRAYS, ONE FOR    *
C      EACH COUNTRY GROUP.  THESE ARRAYS ARE NAMED BY THE FOLLOWING      *
C                                                                        *
C             EXPJJ,                                                     *
C                                                                        *
C      WHERE JJ IS THE ALPHABETIC COUNTRY GROUP INDEX.                   *
C                                                                        *
C      LET YI = INCOME IN ITH TIME PERIOD,                               *
C        RI = INTEREST RATE IN ITH TIME PERIOD                           *
C        KI = GROWTH RATE OF CAPITAL STOCK IN ITH TIME PERIOD,           *
C    AND, MI = GROWTH RATE OF MONEY STOCK IN ITH TIME PERIOD.            *
C                                                                        *
C      THEN EACH VECTOR, EXPJJ , JJ=1,10, IS CONSTRUCTED AS FOLLOWS:     *
C                                                                        *
C   EXPJJ=(Y1,Y2,R1,R2,K1,K2,M1,M2) ,                                    *
C                                                                        *
C WHERE THE SUBSCRIPTS FOLLOW THE TIME INDEXING CONVENTION               *
C DESCRIBED ABOVE.                                                       *
C                                                                        *
C                                                                        *
C B. DOTVAR                                                              *
C                                                                        *
C            DOTVAR CONTAINS THE GROWTH RATES OF INCOME, INTEREST        *
C     RATE, CAPITAL STOCK, AND MONEY STOCK.                              *
C                                                                        *
C            DOTVAR IS EQUIVALENCED TO TEN 1-DIMENSIONAL ARRAYS          *
```

```
C      WITH NAMES AS FOLLOW:                                             *
C                                                                        *
C              CHAJJ,                                                    *
C                                                                        *
C      WHERE JJ IS THE ALPHABETIC COUNTRY GROUP INDEX.                   *
C                                                                        *
C              THEN EACH VECTOR, CHAJJ, JJ=1,20, IS CONSTRUCTED AS       *
C    FOLLOWS:                                                            *
C                                                                        *
C      CHAJJ=(YDOT1,YDOT2,RDOT1,RDOT2,K1,K2,M1,M2),                      *
C                                                                        *
C      WHERE YDOTJ IS RATE OF GROWTH OF INCOME IN THE JTH PERIOD,        *
C          RDOTJ IS RATE OF GROWTH OF INTEREST RATE IN THE JTH PERIOD,   *
C            AND MJ, KJ, AND TIME INDEXING ARE AS FOR EXPARM.            *
C                                                                        *
C                                                                        *
C  C. PRDOT                                                              *
C                                                                        *
C              PRDOT IS NOT EQUIVALENCED TO ANY OTHER ARRAY, BEING ONLY  *
C      1-DIMENSIONAL.  IT IS CONSTRUCTED AS FOLLOWS:                     *
C                                                                        *
C      PRDOT=(PRDOT1,PRDOT2,PRDOT3,PRDOT4),                              *
C                                                                        *
C      WHERE THE FIRST ENTRY IS RATE OF PRICE CHANGE FOR ALUMINUM, THE   *
C      SUBSTITUTE FOR COPPER, THE SECOND ENTRY IS RATE OF PRICE CHANGE   *
C      FOR COPPER THE SUBSTITUTE FOR ALUMINUM, AND THE THIRD AND FOURTH*
C      ENTRIES ARE THE RATE OF PRICE CHANGE FOR STEEL, THE SUBSTITUTE    *
C      FOR BOTH NICKEL AND ZINC.                                         *
C                                                                        *
C                                                                        *
C  D. PRICE                                                              *
C                                                                        *
C              PRICE IS THE ARRAY OF PRICE VALUES FOR THE FOUR MINERALS  *
C      PLUS THE FOUR SUBSTITUTES.  IT IS NOT EQUIVALENCE TO ANY          *
C      ARRAYS. IT IS CONSTRUCTED AS FOLLOWS:                             *
C                                                                        *
C  LET PIJ = THE PRICE OF THE ITH MINERAL IN THE JTH TIME PERIOD, AND    *
C      PRIJ = THE PRICE OF THE SUBSTITUTE FOR THE ITH MINERAL IN THE     *
C             JTH TIME PERIOD,                                           *
C  THEN                                                                  *
C      PRICE=(P11,PR11,P12,PR12,P13,PR13, ------,P43,PR43) .             *
C                                                                        *
C                                                                        *
C  E.  QDEM                                                              *
C                                                                        *
C              QDEM CONTAINS THE VALUES OF DEMAND FOR THE TEN COUNTRY    *
C      GROUPS FOR FOUR TIME PERIODS.  IT IS EQUIVALENCED TO FOUR 1-      *
C      DIMENSIONAL ARRAYS, NAMED AS FOLLOWS:                             *
C                                                                        *
C              QDEMI ,  I = 1,2,3,4,                                     *
C                                                                        *
C      WHERE I IS THE MINERAL INDEX.                                     *
C                                                                        *
C              EACH OF THE ARRAYS QDEMI, I=1,2,3,4, IS CONSTRUCTED AS    *
C      FOLLOWS:                                                          *
C                                                                        *
C      LET DJK = DEMAND FOR THE ITH MINERAL FROM THE JTH COUNTRY GROUP   *
C                 FOR THE KTH YEAR,                                      *
C    THEN                                                                *
C              QDEMI=(D(1,1),D(1,2),D(1,3),D(1,4),----,D(10,4)).         *
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```
C                                                                         *
C                                                                         *
C  F.  QSUP                                                               *
C                                                                         *
C          QSUP CONTAINS THE VALUES OF PRIMARY PRODUCTION (SUPPLY)        *
C      FOR THE TEN COUNTRY GROUPS FOR TWO TIME PERIODS.                   *
C      EQUIVALENCED TO FOUR 1-DIMENSIONAL ARRAYS, NAMED AS FOLLOWS:       *
C                                                                         *
C          QSUPI , I = 1,2,3,4,                                           *
C                                                                         *
C      WHERE I IS THE MINERAL INDEX.                                      *
C                                                                         *
C          EACH OF THE ARRAYS QSUPI, I=1,2,3,4, IS CONSTRUCTED AS         *
C      FOLLOWS:                                                           *
C                                                                         *
C      LET SJK = DEMAND FOR THE ITH MINERAL FROM THE JTH COUNTRY GROUP    *
C              FOR THE KTH YEAR,                                          *
C      THEN                                                               *
C      QSUPI=(S1,1),S(1,2),S(2,1),S(2,2),----------,S(10,1),S(10,2).      *
C                                                                         *
C                                                                         *
C  G.  QSCP                                                               *
C                                                                         *
C          QSCP CONTAINS THE VALUES OF SECONDARY PRODUCTION (SCRAP)       *
C      FOR THE TEN COUNTRY GROUPS FOR TWO TIME PERIODS.  IT IS            *
C      EQUIVALENCED TO FOUR 1-DIMENSIONAL ARRAYS, NAMED AS FOLLOOWS:      *
C                                                                         *
C          QSCPI , I=1,2,3,4,                                             *
C                                                                         *
C      WHERE I IS THE MINERAL INDEX.                                      *
C                                                                         *
C          EACH OF THE ARRAYS QSCPI, I=1,2,3,4, IS CONSTRUCTED            *
C      AS THE QSUPI ABOVE.                                                *
C                                                                         *
C                                                                         *
C  H.  QSPROD                                                             *
C                                                                         *
C          QSPROD CONTAINS THE SUM OF PAST PRODUCTION FOR THE             *
C      TEN COUNTRY GROUPS FOR TWO TIME PERIODS. THE VALUE FOR EACH        *
C      TIME PERIOD IS THE SUM OF PRODUCTION UP TO TIME, T-2. QSPROD       *
C      IS EQUIVALENCED TO FOUR 1-DIMENSIONAL ARRAYS , NAMED AS FOLLOWS:   *
C                                                                         *
C          QSPRDI , I=1,2,3,4                                             *
C                                                                         *
C      WHERE I IS THE MINERAL INDEX.                                      *
C                                                                         *
C          EACH OF THE ARRAYS QSPRDI, I=1,2,3,4, IS CONSTRUCTED           *
C      AS THE QSUPI ABOVE.                                                *
C                                                                         *
C                                                                         *
C                                                                         *
C II. EQUATION COEFFICIENTS                                               *
C                                                                         *
C      A. PRCOEF -- COEFFICIENTS OF PRICE EQUATIONS                       *
C                                                                         *
C          PRCOEF IS EQUIVALENCE TO FOUR 1-DIMENSIONAL ARRAYS,            *
C      NAMED AS FOLLOWS:                                                  *
C                                                                         *
C          PRCFI, I=1,2,3,4;                                              *
C                                                                         *
```

```
C      WHERE I IS THE MINERAL INDEX.                                    *
C                                                                       *
C             EACH OF THE ARRAYS, PRCFI , IS CONSTRUCTED AS FOLLOWS:    *
C                                                                       *
C      LET AJ = THE JTH COEFFICIENT IN THE EQUATION FOR THE PRICE       *
C      OF THE ITH MINERAL, THEN                                         *
C                                                                       *
C      PRCFI=(A1,A2,A3,----------,A14,A15).                             *
C                                                                       *
C      B. DMCOEF,SRCOEF,SPCOEF                                          *
C                                                                       *
C             THESE THREE ARRAYS ARE EQUIVALENCED IN IDENTICAL MANNER   *
C      TO 40 1-DIMENSIONAL ARRAYS, ONE FOR EACH COUNTRY GROUP FOR EACH  *
C      MINERAL, WHICH ARE NAMED IN THE FOLLOWING MANNER:                *
C                                                                       *
C             DMCGI , I=1,2,3,4; FOR DMCOEF,                            *
C             SRCGI , I=1,2,3,4; FOR SRCOEF,                            *
C             SPCGI , I=1,2,3,4; FOR SPCOEF;                            *
C                                                                       *
C      WHERE CG IS THE ALPHABETIC COUNTRY GROUP INDEX.                  *
C                                                                       *
C      THESE ARRAYS ARE CONSTRUCTED SIMILARLY TO THE PRCFI ABOVE.       *
C                                                                       *
C                                                                       *
C-----------------------------------------------------------------------*
C                                                                       *
C             LISTING OF PROGRAM COUNTERS AND PARAMETERS                *
C                                                                       *
C      VARIABLE   FUNCTION             DEFAULT VALUE                    *
C      IYR     BEG. CALCULATION YEAR      80                            *
C      IYRFST  BEG. OUTPUT YEAR           81                            *
C      IYRSIM  # OF YEARS TO SIMULATE     10                            *
C              STARTING WITH IYRFST                                     *
C      ICNTRY  DIM. OF ACTIVE COUN. GRPS  7                             *
C      IWORLD  INDEX FOR WORLD            8                             *
C      IPRICE  # OF COEFFICIENTS IN       11                            *
C              PRICE EQUATION                                           *
C      IQDEM   # OF COEFFICIENTS IN       10                            *
C              DEMAND EQUATIONS                                         *
C      IQSUP   # OF COEFFICIENTS IN       13                            *
C              SUPPLY EQUATIONS                                         *
C      IQSCP   # OF COEFFICIENTS IN       13                            *
C              SCRAP EQUATIONS                                          *
C                                                                       *
C NOTE:  THESE PARAMETERS HAVE THEIR DEFAULT VALUES SET                 *
C      IN THE LAST TWO CARDS IN THE BLOCK DATA SUBROUTINE.              *
C                                                                       *
C                                                                       *
C                                                                       *
C                                                                       *
C                                                                       *
C                   EQUATION PARAMETER                                  *
C                    CROSS REFERENCE                                    *
C                                                                       *
C COEF.                      EQUATION                                   *
C NUMB.  PRICE          DEMAND          SCRAP          SUPPLY           *
C  1     CONSTANT       CONSTANT        CONSTANT       CONSTANT         *
C  2     PRICE(T-1)     PRICEDIF(T)     PRICE(T)       PRICE(T)         *
C  3     PRICE(T-2)     PRICEDIF(T-1)   PRICE(T-1)     PRICE(T-1)       *
C  4     EXCESS SUPPLY  PRICEDIF(T-2)   PRICE(T-2)     PRICE(T-2)       *
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C          INCL. SCRAP
C          FOR T-1                                                            *
C   5      WSSUM(T-1)      EXCESS SUPPLY   QDEM(T)        ROWS(T-1)           *
C                          W/O SCRAP (T-1)                                    *
C   6      T               INCOME(T)       QDEM(T-1)      WORDEM(T)           *
C   7      NA INCOME(T)    INCOME(T-1)     QDEM(T-2)      WORDEM(T-1)         *
C   8      NA INTEREST     CAPITAL GROWTH  QDEM(T-3)      WORDEM(T-2)         *
C          RATE(T)         RATE(T-1)                                          *
C   9      PREL(T)         MONEY GROWTH    QSCP(T-1)      T                   *
C                          RATE(T-1)                                          *
C  10      PREL(T-1)       QDEM(T-1)       WORDEM(T)      INTEREST RATE(T)    *
C  11      PREL(T-2)       NOT USED        WORDEM(T-1)    INTER. RATE(T-2)    *
C  12      NOT USED        NOT USED        WORDEM(T-2)    QSPROD(T)           *
C  13      NOT USED        NOT USED        WORDEM(T-3)    QSUP(T-1)           *
C  14      NOT USED        NOT USED        NOT USED       NOT USED            *
C  15      NOT USED        NOT USED        NOT USED       NOT USED            *
C                                                                             *
C******************************************************************************
      BLOCK DATA
      COMMON / AREOUT / OUTPUT (4,11,25), DOTVAR (4,10), PROOT (4),     BLCK001
     1 ICNT(25), IGRT(25), USRGRT(25), GROW(25)                         BLCK002
      COMMON / AREAPR / PRCOEF(15,4),PSHIFT(50),PRCHA(4)                BLCK003
      COMMON / ARPRIC / PRICE(2,3,4)                                    BLCK004
      COMMON / AREEXP / EXPARM(2,4,10),WPI                              BLCK005
      COMMON / AREAGN / DMCOEF(15,10,4),SRCOEF(15,10,4),                BLCK006
     1 SPCOEF(15,10,4),SHFT(50,30)                                      BLCK007
      COMMON / AREDAT / QDEM(4,10,4),QSUP(2,10,4),QSCP(2,10,4),         BLCK008
     1 QSPROD(2,10,4)                                                   BLCK009
      COMMON / AREANM / NAME (2,4), NAMSUB (2,4), NAMCNT (4,11),        BLCK010
     1  NAMEXT(2,5),NAMVAR(2,4), IYRSFT(20), SHIFT(20), ICTSHT(20),     BLCK011
     2  IVETLB(22,4),ISTAR,IBLANK,IHATCH,IBAR,IPLTVR(3,12),IPLTPR       BLCK012
      COMMON / AREPRM / ICNTRY,IYR,IPRICE,IQDEM,IQSUP,IQSCP,IYRSIM,     BLCK013
     1 IYRFST, NIKCHK,  IWORLD, IANN, IEXCHK, INEW(3), IERROR(14),IPG,  BLCK014
     2 ISVAR(20), ISLEN(20), KVAR(3), IEXTRA, CNEW(3,4), ISCALE(30)     BLCK015
      DIMENSION PRCF1(15),PRCF2(15),PRCF3(15),PRCF4(15),PRCF5(15)       BLCK016
      DIMENSION EXPNA(2,4),EXPSA(2,4),EXPAS(2,4),EXPAF(2,4),EXPEU(2,4), BLCK017
     1EXPOC(2,4),EXPCP(2,4),EXPXX(2,4),EXPYY(2,4),EXPZZ(2,4)            BLCK018
      DIMENSION CHANA(4),CHASA(4),CHAAS(4),CHAAF(4),                    BLCK019
     1CHAEU(4),CHAOC(4),CHACP(4),CHAXX(4),CHAYY(4),CHAZZ(4)             BLCK020
      DIMENSION SPNA1(15),SPSA1(15),SPAS1(15),SPAF1(15),SPEU1(15),      BLCK021
     1SPOC1(15),SPCP1(15),SPXX1(15),SPYY1(15),SPZZ1(15)                 BLCK022
      DIMENSION SPNA2(15),SPSA2(15),SPAS2(15),SPAF2(15),SPEU2(15),      BLCK023
     1SPOC2(15),SPCP2(15),SPXX2(15),SPYY2(15),SPZZ2(15)                 BLCK024
      DIMENSION SPNA3(15),SPSA3(15),SPAS3(15),SPAF3(15),SPEU3(15),      BLCK025
     1SPOC3(15),SPCP3(15),SPXX3(15),SPYY3(15),SPZZ3(15)                 BLCK026
      DIMENSION SPNA4(15),SPSA4(15),SPAS4(15),SPAF4(15),SPEU4(15),      BLCK027
     1SPOC4(15),SPCP4(15),SPXX4(15),SPYY4(15),SPZZ4(15)                 BLCK028
      DIMENSION DMNA1(15),DMSA1(15),DMAS1(15),DMAF1(15),DMEU1(15),      BLCK029
     1DMOC1(15),DMCP1(15),DMXX1(15),DMYY1(15),DMZZ1(15)                 BLCK030
      DIMENSION DMNA2(15),DMSA2(15),DMAS2(15),DMAF2(15),DMEU2(15),      BLCK031
     1DMOC2(15),DMCP2(15),DMXX2(15),DMYY2(15),DMZZ2(15)                 BLCK032
      DIMENSION DMNA3(15),DMSA3(15),DMAS3(15),DMAF3(15),DMEU3(15),      BLCK033
     1DMOC3(15),DMCP3(15),DMXX3(15),DMYY3(15),DMZZ3(15)                 BLCK034
      DIMENSION DMNA4(15),DMSA4(15),DMAS4(15),DMAF4(15),DMEU4(15),      BLCK035
     1DMOC4(15),DMCP4(15),DMXX4(15),DMYY4(15),DMZZ4(15)                 BLCK036
      DIMENSION SRNA1(15),SRSA1(15),SRAS1(15),SRAF1(15),SREU1(15),      BLCK037
     1SROC1(15),SRCP1(15),SRXX1(15),SRYY1(15),SRZZ1(15)                 BLCK038
      DIMENSION SRNA2(15),SRSA2(15),SRAS2(15),SRAF2(15),SREU2(15),      BLCK039
     1SROC2(15),SRCP2(15),SRXX2(15),SRYY2(15),SRZZ2(15)                 BLCK040
      DIMENSION SRNA3(15),SRSA3(15),SRAS3(15),SRAF3(15),SREU3(15),      BLCK041
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1SROC3(15),SRCP3(15),SRXX3(15),SRYY3(15),SRZZ3(15)                      BLCK043
 DIMENSION SRNA4(15),SRSA4(15),SRAS4(15),SRAF4(15),SREU4(15),           BLCK044
1SROC4(15),SRCP4(15),SRXX4(15),SRYY4(15),SRZZ4(15)                      BLCK045
 DIMENSION QDEM1(4,10),QDEM2(4,10),QDEM3(4,10),QDEM4(4,10)              BLCK046
 DIMENSION QSUP1(2,10),QSUP2(2,10),QSUP3(2,10),QSUP4(2,10)              BLCK047
 DIMENSION QSCP1(2,10),QSCP2(2,10),QSCP3(2,10),QSCP4(2,10)              BLCK048
 DIMENSION QSPRD1(2,10),QSPRD2(2,10),QSPRD3(2,10),QSPRD4(2,10)          BLCK049
 EQUIVALENCE (PRCOEF(1,1),PRCF1(1)),(PRCOEF(1,2),PRCF2(1)),             BLCK050
1 (PRCOEF(1,3),PRCF3(1)),(PRCOEF(1,4),PRCF4(1))                         BLCK051
 EQUIVALENCE (EXPARM(1,1,1),EXPNA(1)),(EXPARM(1,1,2),EXPSA(1)),         BLCK052
1(EXPARM(1,1,3),EXPAS(1)),(EXPARM(1,1,4),EXPAF(1)),                     BLCK053
2(EXPARM(1,1,5),EXPEU(1)),(EXPARM(1,1,6),EXPOC(1)),                     BLCK054
3(EXPARM(1,1,7),EXPCP(1)),(EXPARM(1,1,8),EXPXX(1)),                     BLCK055
4(EXPARM(1,1,9),EXPYY(1)),(EXPARM(1,1,10),EXPZZ(1))                     BLCK056
 EQUIVALENCE (DOTVAR(1,1),CHANA(1)),(DOTVAR(1,2),CHASA(1)),             BLCK057
1(DOTVAR(1,3),CHAAS(1)),(DOTVAR(1,4),CHAAF(1)),                         BLCK058
2(DOTVAR(1,5),CHAEU(1)),(DOTVAR(1,6),CHAOC(1)),                         BLCK059
3(DOTVAR(1,7),CHACP(1)),(DOTVAR(1,8),CHAXX(1)),                         BLCK060
4(DOTVAR(1,9),CHAYY(1)),(DOTVAR(1,10),CHAZZ(1))                         BLCK061
 EQUIVALENCE (SPCOEF(1,1,1),SPNA1(1)),(SPCOEF(1,2,1),SPSA1(1)),         BLCK062
1(SPCOEF(1,3,1),SPAS1(1)),(SPCOEF(1,4,1),SPAF1(1)),                     BLCK063
2(SPCOEF(1,5,1),SPEU1(1)),(SPCOEF(1,6,1),SPOC1(1)),                     BLCK064
3(SPCOEF(1,7,1),SPCP1(1)),(SPCOEF(1,8,1),SPXX1(1)),                     BLCK065
4(SPCOEF(1,9,1),SPYY1(1)),(SPCOEF(1,10,1),SPZZ1(1))                     BLCK066
 EQUIVALENCE (SPCOEF(1,1,2),SPNA2(1)),(SPCOEF(1,2,2),SPSA2(1)),         BLCK067
1(SPCOEF(1,3,2),SPAS2(1)),(SPCOEF(1,4,2),SPAF2(1)),                     BLCK068
2(SPCOEF(1,5,2),SPEU2(1)),(SPCOEF(1,6,2),SPOC2(1)),                     BLCK069
3(SPCOEF(1,7,2),SPCP2(1)),(SPCOEF(1,8,2),SPXX2(1)),                     BLCK070
4(SPCOEF(1,9,2),SPYY2(1)),(SPCOEF(1,10,2),SPZZ2(1))                     BLCK071
 EQUIVALENCE (SPCOEF(1,1,3),SPNA3(1)),(SPCOEF(1,2,3),SPSA3(1)),         BLCK072
1(SPCOEF(1,3,3),SPAS3(1)),(SPCOEF(1,4,3),SPAF3(1)),                     BLCK073
2(SPCOEF(1,5,3),SPEU3(1)),(SPCOEF(1,6,3),SPOC3(1)),                     BLCK074
3(SPCOEF(1,7,3),SPCP3(1)),(SPCOEF(1,8,3),SPXX3(1)),                     BLCK075
4(SPCOEF(1,9,3),SPYY3(1)),(SPCOEF(1,10,3),SPZZ3(1))                     BLCK076
 EQUIVALENCE (SPCOEF(1,1,4),SPNA4(1)),(SPCOEF(1,2,4),SPSA4(1)),         BLCK077
1(SPCOEF(1,3,4),SPAS4(1)),(SPCOEF(1,4,4),SPAF4(1)),                     BLCK078
2(SPCOEF(1,5,4),SPEU4(1)),(SPCOEF(1,6,4),SPOC4(1)),                     BLCK079
3(SPCOEF(1,7,4),SPCP4(1)),(SPCOEF(1,8,4),SPXX4(1)),                     BLCK080
4(SPCOEF(1,9,4),SPYY4(1)),(SPCOEF(1,10,4),SPZZ4(1))                     BLCK081
 EQUIVALENCE (DMCOEF(1,1,1),DMNA1(1)),(DMCOEF(1,2,1),DMSA1(1)),         BLCK082
1(DMCOEF(1,3,1),DMAS1(1)),(DMCOEF(1,4,1),DMAF1(1)),                     BLCK083
2(DMCOEF(1,5,1),DMEU1(1)),(DMCOEF(1,6,1),DMOC1(1)),                     BLCK084
3(DMCOEF(1,7,1),DMCP1(1)),(DMCOEF(1,8,1),DMXX1(1)),                     BLCK085
4(DMCOEF(1,9,1),DMYY1(1)),(DMCOEF(1,10,1),DMZZ1(1))                     BLCK086
 EQUIVALENCE (DMCOEF(1,1,2),DMNA2(1)),(DMCOEF(1,2,2),DMSA2(1)),         BLCK087
1(DMCOEF(1,3,2),DMAS2(1)),(DMCOEF(1,4,2),DMAF2(1)),                     BLCK088
2(DMCOEF(1,5,2),DMEU2(1)),(DMCOEF(1,6,2),DMOC2(1)),                     BLCK089
3(DMCOEF(1,7,2),DMCP2(1)),(DMCOEF(1,8,2),DMXX2(1)),                     BLCK090
4(DMCOEF(1,9,2),DMYY2(1)),(DMCOEF(1,10,2),DMZZ2(1))                     BLCK091
 EQUIVALENCE (DMCOEF(1,1,3),DMNA3(1)),(DMCOEF(1,2,3),DMSA3(1)),         BLCK092
1(DMCOEF(1,3,3),DMAS3(1)),(DMCOEF(1,4,3),DMAF3(1)),                     BLCK093
2(DMCOEF(1,5,3),DMEU3(1)),(DMCOEF(1,6,3),DMOC3(1)),                     BLCK094
3(DMCOEF(1,7,3),DMCP3(1)),(DMCOEF(1,8,3),DMXX3(1)),                     BLCK095
4(DMCOEF(1,9,3),DMYY3(1)),(DMCOEF(1,10,3),DMZZ3(1))                     BLCK096
 EQUIVALENCE (DMCOEF(1,1,4),DMNA4(1)),(DMCOEF(1,2,4),DMSA4(1)),         BLCK097
1(DMCOEF(1,3,4),DMAS4(1)),(DMCOEF(1,4,4),DMAF4(1)),                     BLCK098
2(DMCOEF(1,5,4),DMEU4(1)),(DMCOEF(1,6,4),DMOC4(1)),                     BLCK099
3(DMCOEF(1,7,4),DMCP4(1)),(DMCOEF(1,8,4),DMXX4(1)),                     BLCK100
4(DMCOEF(1,9,4),DMYY4(1)),(DMCOEF(1,10,4),DMZZ4(1))                     BLCK101
 EQUIVALENCE (SRCOEF(1,1,1),SRNA1(1)),(SRCOEF(1,2,1),SRSA1(1)),         BLCK102
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      1(SRCOEF(1,3,1),SRAS1(1)),(SRCOEF(1,4,1),SRAF1(1)),
      2(SRCOEF(1,5,1),SREU1(1)),(SRCOEF(1,6,1),SROC1(1)),                 BLCK103
      3(SRCOEF(1,7,1),SRCP1(1)),(SRCOEF(1,8,1),SRXX1(1)),                 BLCK104
      4(SRCOEF(1,9,1),SRYY1(1)),(SRCOEF(1,10,1),SRZZ1(1))                 BLCK105
       EQUIVALENCE (SRCOEF(1,1,2),SRNA2(1)),(SRCOEF(1,2,2),SRSA2(1)),     BLCK106
      1(SRCOEF(1,3,2),SRAS2(1)),(SRCOEF(1,4,2),SRAF2(1)),                 BLCK107
      2(SRCOEF(1,5,2),SREU2(1)),(SRCOEF(1,6,2),SROC2(1)),                 BLCK108
      3(SRCOEF(1,7,2),SRCP2(1)),(SRCOEF(1,8,2),SRXX2(1)),                 BLCK109
      4(SRCOEF(1,9,2),SRYY2(1)),(SRCOEF(1,10,2),SRZZ2(1))                 BLCK110
       EQUIVALENCE (SRCOEF(1,1,3),SRNA3(1)),(SRCOEF(1,2,3),SRSA3(1)),     BLCK111
      1(SRCOEF(1,3,3),SRAS3(1)),(SRCOEF(1,4,3),SRAF3(1)),                 BLCK112
      2(SRCOEF(1,5,3),SREU3(1)),(SRCOEF(1,6,3),SROC3(1)),                 BLCK113
      3(SRCOEF(1,7,3),SRCP3(1)),(SRCOEF(1,8,3),SRXX3(1)),                 BLCK114
      4(SRCOEF(1,9,3),SRYY3(1)),(SRCOEF(1,10,3),SRZZ3(1))                 BLCK115
       EQUIVALENCE (SRCOEF(1,1,4),SRNA4(1)),(SRCOEF(1,2,4),SRSA4(1)),     BLCK116
      1(SRCOEF(1,3,4),SRAS4(1)),(SRCOEF(1,4,4),SRAF4(1)),                 BLCK117
      2(SRCOEF(1,5,4),SREU4(1)),(SRCOEF(1,6,4),SROC4(1)),                 BLCK118
      3(SRCOEF(1,7,4),SRCP4(1)),(SRCOEF(1,8,4),SRXX4(1)),                 BLCK119
      4(SRCOEF(1,9,4),SRYY4(1)),(SRCOEF(1,10,4),SRZZ4(1))                 BLCK120
       EQUIVALENCE (QDEM(1,1,1),QDEM1(1)),(QDEM(1,1,2),QDEM2(1)),         BLCK121
      1 (QDEM(1,1,3),QDEM3(1)),(QDEM(1,1,4),QDEM4(1))                     BLCK122
       EQUIVALENCE (QSUP(1,1,1),QSUP1(1)),(QSUP(1,1,2),QSUP2(1)).         BLCK123
      1 (QSUP(1,1,3),QSUP3(1)),(QSUP(1,1,4),QSUP4(1))                     BLCK124
       EQUIVALENCE (QSCP(1,1,1),QSCP1(1)),(QSCP(1,1,2),QSCP2(1)),         BLCK125
      1 (QSCP(1,1,3),QSCP3(1)),(QSCP(1,1,4),QSCP4(1))                     BLCK126
       EQUIVALENCE (QSPROD(1,1,1),QSPRD1(1)),(QSPROD(1,1,2),QSPRD2(1)),   BLCK127
      1 (QSPROD(1,1,3),QSPRD3(1)),(QSPROD(1,1,4),QSPRD4(1))               BLCK128
C*********************************************************************** BLCK129
C                                                                      *
C                                                                      *
C   SET UP INTEGER ARRAYS WITH NAMES FOR PRINT FORMATTING.             *
C                                                                      *
C***********************************************************************
       DATA NAME / 4H COP, 4HPER , 4HALUM, 4HINUM, 4H NIC, 4HKEL ,        BLCK130
      1 4H  ZI, 4HNC  /                                                   BLCK131
       DATA NAMSUB / 4HALUM, 4HINUM, 4H COP, 4HPER , 4H  ST, 4HEEL ,      BLCK132
      1 4H  ST, 4HEEL  /                                                  BLCK133
       DATA NAMCNT / 4H  NO, 4HRTH , 4HAMER, 4HICA , 4H  SO, 4HUTH ,      BLCK134
      1 4HAMER, 4HICA , 4H    , 4H  AS, 4HIA  , 4H    , 4H    ,           BLCK135
      2 4H AFR, 4HICA , 4H    , 4H    , 4H EUR, 4HOPE , 4H    ,           BLCK136
      3  4H    , 4HOCEA, 4HNIA , 4H    , 4HCENT,                          BLCK137
      4 4HRAL , 4HPLAN, 4HNED , 4H    , 4H  WO, 4HRLD , 4H    , 12*0 /    BLCK138
       DATA NAMEXT / 4H INC, 4HOME , 4HINTE, 4HREST, 4H CAP, 4HITAL,      BLCK139
      1  4H  MO, 4HNEY , 4HSUBS, 4HTUTE   /                               BLCK140
       DATA NAMVAR / 4H SUP, 4HPLY , 4H  SC, 4HRAP , 4H DEM, 4HAND ,      BLCK141
      1  4H  PR, 4HICE     /                                              BLCK142
       DATA IVETLB /  1HS, 1HU, 1HP, 1HP, 1HL, 1HY,                       BLCK143
      1  16*' ', 1HS, 1HC, 1HR, 1HA, 1HP, 1H ,                            BLCK144
      2  16*' ', 1HU, 1HE, 1HM, 1HA, 1HN, 1HD,                            BLCK145
      3  16*' ', 1HP, 1HR, 1HI, 1HC, 1HE, 1H , 16*' ' /                   BLCK146
       DATA ISTAR, IBLANK, IMATCH, IBAR / 1H* , 1H  ,1HI, 1H- /           BLCK147
       DATA KVAR / 2, 1, 0 /                                              BLCK148
       DATA FSHIFT,SHFT,CNEW,WPI / 1550*1.0, 12*0.0, 2.356 /              BLCK149
       DATA IERCHK,INEW,IERROR,NIKCHK,ISCALE,IPLTVR,IPLTPR / 86*0 /       BLCK150
       DATA OUTPUT,OSHORT,GROW,PRCHA,SHIFT / 1174*0.0 /                   BLCK151
       DATA ICNT,IGRT,IANN,IPG,ISVAR,ISLEN,IEXTRA,IYRSFT,ICTSHT / 133*0 / BLCK152
C***********************************************************************
C                                                                      *
C        NOW SET UP SUPPLY COEFFICIENTS                                *
C                                                                      *
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C*******************************************************************
      DATA SPNA1 / 300.892, 0.0, 6.2325, 0.0, 0.6708, .5061, -.2436,    BLCK153
     1 0.0, -30.144, 26.5248, 101.981, -.081, .228, 2*0.0 /             BLCK154
      DATA SPSA1/ -1217.08, .3697, -1.6621, 5*0.0, 32.8896, 2*0.0,      BLCK155
     1 -.0039, .0578, 2*0.0 /                                           BLCK156
      DATA SPAS1 / 85.4435, .4449, .7336, 0.0, .0419, .0231, -.0433,    BLCK157
     1 0.0, -2.9154, 2*0.0, -.003, .9707, 2*0.0 /                       BLCK158
      DATA SPAF1 / -1063.49, 3*0.0, -.0138, .0521, .0079, 0.0, 27.2426, BLCK159
     1 2*0.0, -.0055, .1541, 2*0.0 /                                    BLCK160
      DATA SPEU1 / -12.5699, 0.0, .0511, 2*0.0, .0079, -.0027,          BLCK161
     1 4*0.0, -.0004, .9330, 2*0.0 /                                    BLCK162
      DATA SPOC1 / -45.0941, 3*0.0, .0203, .027, -.0299, 5*0.0,         BLCK163
     1 .8542, 2*0.0 /                                                   BLCK164
      DATA SPCP1 / -239.112, 0.0, 1.1908, 5*0.0,  4.3026, 2*0.0,        BLCK165
     1 -.0034, .9896, 2*0.0 /                                           BLCK166
      DATA SPXX1,SPYY1,SPZZ1 /  45*0.0 /                                BLCK167
      DATA SPNA2 / -359.146, 44.8745, 2.4725, 0.0, -0.5353, 0.3532,     BLCK168
     1 0.3824, 4*0.0, -0.0042, -0.0933, 2*0.0 /                         BLCK169
      DATA SPSA2 / -64.8237, 5.9235, -3.1790, 2*0.0, 0.0056,            BLCK170
     1 5*0.0, 0.0186, 0.8346, 2*0.0 /                                   BLCK171
      DATA SPAS2 / -255.296, 0.0, 9.3518, 3*0.0, 0.0286,                BLCK172
     1 5*0.0, 0.8424, 2*0.0 /                                           BLCK173
      DATA SPAF2 / -82.5312, 0.0, 1.8953, 2*0.0, 0.0092,                BLCK174
     1 6*0.0, 0.8017, 2*0.0 /                                           BLCK175
      DATA SPEU2 / 840.791, 1.6431, -7.8384, 0.0, 0.0355,               BLCK176
     1 0.0579, 0.0395, 0.0, -13.0657, 2*0.0, 0.028, 0.3341, 2*0.0 /     BLCK177
      DATA SPOC2 / -5.5657, 4.3082, 1.3817, 0.0, 0.0064, 0.0187,        BLCK178
     1 -0.0049, 0.0, -4.0795, -5.7795, 10.6340, -0.0101,                BLCK179
     2  0.7664, 2*0.0 /                                                 BLCK180
      DATA SPCP2 / -2340.19, 15.1127, -1.8014, 0.0, 0.1212, 0.0868,     BLCK181
     1 -0.0022, 0.0, 46.8268, 2*0.0, 0.0013, -0.1936, 2*0.0 /           BLCK182
      DATA SPXX2,SPYY2,SPZZ2 /  45*0.0 /                                BLCK183
      DATA SPNA3 / -357.182, 1.3088, -0.4006, 0.0, -0.3506, 0.2007,     BLCK184
     1 0.3220, 0.0, 17.2693, 0.0, 10.5975, -0.0873, -0.2648, 2*0.0 /    BLCK185
      DATA SPSA3 / 53.4602, 0.0, 0.2931, 0.0, -0.0698, 0.0757, 0.0811,  BLCK186
     1 0.0, -2.0665, 2*0.0, 0.0592, 0.3593, 2*0.0 /                     BLCK187
      DATA SPAS3 / -21.6653, 0.1378, -0.0828, 0.0, -0.0020, -0.0105,    BLCK188
     1 0.0022, 0.0, 0.3727, 2*0.0, 0.1173, 0.0637, 2*0.0 /              BLCK189
      DATA SPAF3 / 53.1613, 0.0, 0.3381, 0.0, -0.0049, 0.0328,          BLCK190
     1 0.0359, 0.0, -2.0038, 2*0.0, 0.2845, -0.6650, 2*0.0 /            BLCK191
      DATA SPEU3 / 12.9107, 0.1138, 0.0210, 0.0, -0.0, 0.0268,          BLCK192
     1 -0.0037, 0.0, -0.5123, -0.1084, 0.3058, 0.0252, 0.6059, 2*0.0 /  BLCK193
      DATA SPOC3 / 6.3529, 1.4465, -0.1159, 0.0, -0.0219, 0.1373,       BLCK194
     1 0.1978, 0.0, -3.4541, 11.3332, 9.3204, -0.0364, -0.1474,         BLCK195
     2  2*0.0 /                                                         BLCK196
      DATA SPCP3 / -9.0553, 1.4350, -1.0362, 0.0, 0.1397, 0.0555,       BLCK197
     1 -0.0265, 0.0, 0.9874, 2*0.0, -0.0492, 0.4269,  2*0.0 /           BLCK198
      DATA SPXX3,SPYY3,SPZZ3 /  45*0.0 /                                BLCK199
      DATA SPNA4 / -2290.86, 0.0, 35.9861, 0.0, 0.1033, 0.3176, 0.0921, BLCK200
     1 0.0, 25.4613, 1.0545, 6.5047, -0.0749, 0.4614,2*0.0 /            BLCK201
      DATA SPSA4 / 2334.92, 0.0, 0.5355, 0.0, 0.0059, 0.0868, -0.0197,  BLCK202
     1 0.0, -45.0289, 2*0.0, 0.0876, 0.3139, 2*0.0 /                    BLCK203
      DATA SPAS4 / -698.097, 5.1231, 0.7384, 0.0, 0.0583, 0.0036,       BLCK204
     1 -0.0242, 0.0, 10.5899, 2*0.0, -0.0489, 0.7071, 2*0.0 /           BLCK205
      DATA SPAF4 / -4582.93, 0.0, 2.702, 0.0, -0.0288, 0.0,             BLCK206
     1 0.0222, 0.0, 94.5641, 2*0.0, -0.3663, -0.0614, 2*0.0 /           BLCK207
      DATA SPEU4 / -2231.52, 9.1588, -3.099, 0.0, 0.0721, 0.0596,       BLCK208
     1 -0.1097, 0.0, 41.5993, 18.6497, 5.0576, -0.0893, 0.7367, 2*0.0 / BLCK209
      DATA SPOC4 / -1331.89, 0.0, 5.2670, 0.0, 0.0461, 0.0622, 0.0413,  BLCK210
     1 0.0, 21.2747, -27.3258, 49.0637, -0.1078, 0.1803 , 2*0.0 /       BLCK211
```

```
      DATA SPCP4 / -250.63, 0.0, 6.668, 0.0, 0.0358, 0.0463, 0.0378,       BLCK212
     1 0.0, 1.5083, 2*0.0, -0.0032, 0.6321, 2*0.0 /                        BLCK213
      DATA SPXX4,SPYY4,SPZZ4 /  45*0.0 /                                   BLCK214
C*********************************************************************
C                                                                    *
C        NOW SET UP DEMAND COEFFICIENTS                              *
C                                                                    *
C                                                                    *
C*********************************************************************
      DATA DMNA1 / -768.371, 2*0.0, -3.7993, -.2163, 5367.68,              BLCK215
     1 -3488.63, 64.1942, 6.6888, .1313, 5*0.0 /                           BLCK216
      DATA DMSA1 / -593.065, -.5497, -2.1104, 0.0, -.0694, 649.865,        BLCK217
     1 112.119, -80.1161, 0.0, -.1371, 5*0.0 /                             BLCK218
      DATA DMAS1 / -1189.654, 0.0, -2.1243, 2*0.0, 1457.17, 448.012,       BLCK219
     1 1056.26, 0.0, -.3964, 5*0.0 /                                       BLCK220
      DATA DMAF1 / -99.2238, 0.0, -.2709, 0.0, .006, 1.2502, 117.147,      BLCK221
     1 -93.5441, 0.0, .0346 , 5*0.0 /                                      BLCK222
      DATA DMEU1 / -298.0583, -.3387, -10.9103, 0.0, -.166, 0.0,           BLCK223
     1 2390.87, 2330.78, -10.6219, .0986, 5*0.0 /                          BLCK224
      DATA DMOC1 / -95.7724, 0.0, -.3493, 0.0, -.0131, 244.232,            BLCK225
     1 -99.0476, 166.307, -.2543, .2847, 5*0.0 /                           BLCK226
      DATA DMCP1 /-40.5509,0.0, -1.0715, 0.0, -.049, 0.0, 509.117,         BLCK227
     1 2*0.0, .6749, 5*0.0 /                                               BLCK228
      DATA DMXX1,DMYY1,DMZZ1 /  45*0.0 /                                   BLCK229
      DATA DMNA2 / -6071.38, -7.4294, 11.5289, 2*0.0, 9234.44,             BLCK230
     1 3*0.0, 0.0337, 5*0.0 /                                              BLCK231
      DATA DMSA2 / -576.526, -0.5681, 1.323, 0.0, -0.0318, 12.5735,        BLCK232
     1 823.074, 7.7562, 0.0, 0.1024, 5*0.0 /                               BLCK233
      DATA DMAS2 / -1311.98, 4*0.0, 6395.91, -4528.01, 1471.78, 0.0,       BLCK234
     1 0.1720, 5*0.0 /                                                     BLCK235
      DATA DMAF2 / -277.958, -0.1813, 0.0787, 0.0, 0.0048, 145.537,        BLCK236
     1 205.501, -33.0556, 0.0, 0.1267,  5*0.0/                             BLCK237
      DATA DMEU2 / -775.580, -6.3905, 3.9309, 0.0, 0.0516, 6105.14,        BLCK238
     1 -4406.15, -802.369, 10.5161, 0.5822, 5*0.0 /                        BLCK239
      DATA DMOC2 / -314.555, 0.0, -0.089, 0.0, 0.0006, 221.562,            BLCK240
     1 203.59, 11.3577, 0.9156, -0.3256, 5*0.0 /                           BLCK241
      DATA DMCP2 / -176.856, -1.2201, -1.7754, 0.0, 0.0421, 1193.0,        BLCK242
     1 -206.201, 2*0.0, 0.5942, 5*0.0 /                                    BLCK243
      DATA DMXX2,DMYY2,DMZZ2 /  45*0.0 /                                   BLCK244
      DATA DMNA3 / -115.0128, 0.0, -0.8062, 0.0, -0.1136, 294.111,         BLCK245
     1 -26.5806, 59.8842, 0.5157, -0.0431, 5*0.0 /                         BLCK246
      DATA DMSA3 / -13.6289, 4*0.0, 32.6026, -15.9706, 2*0.0,              BLCK247
     1 0.2464,  5*0.0 /                                                    BLCK248
      DATA DMAS3 / -35.2326, 4*0.0, 486.279, -408.513, 91.7363, 0.0,       BLCK249
     1 0.3353, 5*0.0 /                                                     BLCK250
      DATA DMAF3 / -2.1142, 4*0.0, 1.3058, 2.0994, 2*0.0, 0.7314,          BLCK251
     1 5*0.0 /                                                             BLCK252
      DATA DMEU3 / -146.2316, 0.0, -0.4728, 0.0, -0.0792, 374.079,         BLCK253
     1 -51.5532, 9.9632, -0.5350, -0.2065 , 5*0.0 /                        BLCK254
      DATA DMOC3 / -11.5946, 0.0, -0.0222, 0.0, -0.0023, 7.1330,           BLCK255
     1 7.5541, 1.4068, 0.0159, -0.4507 , 5*0.0 /                           BLCK256
      DATA DMCP3 / 18.2909, -0.3387, -0.2333, 0.0, 0.0116, -3.9232,        BLCK257
     1 52.3432 , 2*0.0, 0.5419, 5*0.0 /                                    BLCK258
      DATA DMXX3,DMYY3,DMZZ3 /  45*0.0 /                                   BLCK259
      DATA DMNA4 / -203.0101, -2.8987, 3.2184, 0.0, -0.0617, 4343.4,       BLCK260
     1 -3860.77, -618.125, -2.0851, 0.5883, 5*0.0 /                        BLCK261
      DATA DMSA4 / -424.4377, 0.0, -0.4698, 0.0, -0.0103, 410.939,         BLCK262
     1 185.553, -33.0869, 0.0, -0.4558, 5*0.0 /                            BLCK263
      DATA DMAS4 / -829.729, 0.0, -5.9813, 0.0, 0.1954, -138.384,          BLCK264
     1 544.953, 609.876, 0.0, 0.5036, 5*0.0 /                              BLCK265
      DATA DMAF4 / -194.291, 2*0.0, -1.2465, 0.0222, 187.079,              BLCK266
     1 -11.4363, -85.4222, 0.0, -0.0218, 5*0.0 /                       BLCK267
      DATA DMEU4 / -477.111, 0.0, -5.9412, 0.0, -0.0641, 2617.49,       BLCK268
     1 -1262.81, 360.746, 1.4573, -0.1176, 5*0.0 /                      BLCK269
      DATA DMOC4 / -104.5678, 0.0, -0.7599, 0.0, -0.0113, 55.9709,      BLCK270
     1 113.669, 27.5280, 0.0634, -0.3237, 5*0.0 /                       BLCK271
      DATA DMCP4 / -14.7821, 4*0.0, 764.045, -235.507, 2*0.0,           BLCK272
     1 0.5233, 5*0.0 /                                                  BLCK273
      DATA DMXX4,DMYY4,DMZZ4 /  45*0.0 /                                BLCK274
C*****************************************************************
C                                                                *
C        NOW SET UP SCRAP COEFFICIENTS                           *
C                                                                *
C*****************************************************************
      DATA SRNA1 / -42.9657, 2.564, -1.6662, 0.0, .0689, .0112,         BLCK275
     1 -.0103, 0.0, .0666, 6*0.0 /                                      BLCK276
      DATA SRSA1 / -15.797, .2370, -.0086, 0.0, .0442, -.022,           BLCK277
     1 .0496, 0.0, .0242, 6*0.0 /                                       BLCK278
      DATA SRAS1 / .1277, .5298, -.1909, 0.0, .0631, .0337, -.0483,     BLCK279
     1 0.0, .3493, 6*0.0 /                                              BLCK280
      DATA SRAF1 / 15*0.0 /                                             BLCK281
      DATA SREU1 / -70.9817, 3.0077, -0.3807, 0.0, .0474, -.0593,       BLCK282
     1 .079, 0.0, .5421, 6*0.0 /                                        BLCK283
      DATA SROC1 / -19.0611, .2158, -.055, .3801, .2281, .1949,         BLCK284
     1 -.2247, .0138, 0.0, 6*0.0 /                                      BLCK285
      DATA SRCP1,SRXX1,SRYY1,SRZZ1 /  60*0.0 /                          BLCK286
      DATA SRNA2 / -54.7408, 2.8214, -1.0774, 0.0, 0.105, -0.0716,      BLCK287
     1 0.0569, 0.0, 0.6935, 6*0.0 /                                     BLCK288
      DATA SRSA2 / 2.9039, 0.2940, -0.5360, 0.0, 0.1267, 0.0176,        BLCK289
     1 -0.0032, 0.0, 0.3777, 6*0.0 /                                    BLCK290
      DATA SRAS2 / -10.7487, 2*0.0, 0.4498, 0.2167, 0.0047,             BLCK291
     1 -0.1365, 0.0213, 0.6317, 6*0.0 /                                 BLCK292
      DATA SRAF2 / -0.9371, 0.0207, 0.0335, 0.0, 0.0142, 0.0014,        BLCK293
     1 -0.0050, 0.0, 0.6835, 6*0.0 /                                    BLCK294
      DATA SREU2 / -29.7566, 0.0, 1.8970, 0.0, 0.2579, -0.1538,         BLCK295
     1 0.0164, 0.0, 0.6279, 6*0.0 /                                     BLCK296
      DATA SROC2 / -1.7844,2*0.0, 0.0245, 0.122, -0.0357,               BLCK297
     1 -0.0795, 0.1173, 0.3942, 6*0.0 /                                 BLCK298
      DATA SRCP2,SRXX2,SRYY2,SRZZ2 /  60*0.0 /                          BLCK299
      DATA SRNA3 / -4.7355, 0.0, 0.1414, 5*0.0, 0.5675, 0.0188, -0.0053, BLCK300
     1 -0.0175, 3*0.0 /                                                 BLCK301
      DATA SRSA3,SRAS3,SRAF3,SREU3,SROC3,SRCP3,SRXX3,SRYY3,SRZZ3/       BLCK302
     1      135*0.0 /                                                   BLCK303
      DATA SRNA4 / 113.399, 3.241, 0.6341, 5*0.0, 0.5037, 0.1557,       BLCK304
     1 -0.0942, -0.0229, 3*0.0 /                                        BLCK305
      DATA SRSA4,SRAS4,SRAF4,SREU4,SROC4,SRCP4,SRXX4,SRYY4,SRZZ4/       BLCK306
     1      135*0.0 /                                                   BLCK307
C*****************************************************************
C                                                                *
C   NOW SETUP PRCOEF, PRDOT, AND PRICE.                          *
C                                                                *
C*****************************************************************
      DATA PRCF1 / -39.4101, 0.2523, -0.0162, -0.0292, 0.0 , 0.9166,    BLCK308
     1 0.0, 0.1234, -0.7757, 6*0.0 /                                    BLCK309
      DATA PRCF2 / 16.8802, 1.0090, -0.3765, 0.0001, 2*0.0, -17.8384,   BLCK310
     1 1.1989, 0.0458, 6*0.0 /                                          BLCK311
      DATA PRCF3 / 25.9284, 0.8082, -0.1853, -0.0140, 2*0.0, 0.8189,    BLCK312
     1 5.1756, 0.0, 0.5195, -0.7244, 4*0.0 /                            BLCK313
      DATA PRCF4 / 74.9847, 0.5423, -0.2490, -0.0026,  0.0005, -1.4996, BLCK314
     1 -0.5750, -0.7031, 0.1216, -0.2720, 0.1989, 4*0.0 /               BLCK315
      DATA PRDOT / -0.001, 0.0355, 0.0276, 0.0276 /                     BLCK316
      DATA PRICE / 2*0.0, 35.27, 25.21, 30.80, 25.36,                   BLCK317
     1 2*0.0, 25.21, 35.27, 25.36, 30.80,                               BLCK318
     2 2*0.0, 115.24, 128.183, 99.90, 135.155,                          BLCK319
     3 2*0.0, 15.83, 128.183, 14.80, 135.155 /                          BLCK320
C*********************************************************************
C                                                                    *
C   NOW SETUP EXPARM AND OUTVAR.                                     *
C                                                                    *
C*********************************************************************
      DATA EXPNA / 0.0, 1.24, 0.0, 9.42, 0.0, 0.0385, 0.0, 5.72  /      BLCK321
      DATA EXPSA / 0.0, 1.30, 3*0.0, 0.0693 , 2*0.0 /                   BLCK322
      DATA EXPAS / 0.0, 1.53, 3*0.0, 0.1219 ,2*0.0 /                    BLCK323
      DATA EXPAF / 0.0, 1.20, 3*0.0, 0.0745, 2*0.0 /                    BLCK324
      DATA EXPEU / 0.0, 1.26, 0.0, 9.33, 0.0, 0.0393, 0.0, 10.12 /      BLCK325
      DATA EXPOC / 0.0, 1.20, 0.0, 10.08 , 0.0, 0.0438, 0.0, 15.99 /    BLCK326
      DATA EXPCP / 0.0, 1.55, 6*0.0 /                                   BLCK327
      DATA EXPXX,EXPYY,EXPZZ /  24*0.0 /                                BLCK328
      DATA CHANA / .0276, .0512, 0.0385, 5.31  /                        BLCK329
      DATA CHASA / .0293, 0.0, 0.0693, 0.0 /                            BLCK330
      DATA CHAAS / .045, 0.0, .1219, 0.0 /                              BLCK331
      DATA CHAAF / .0183, 0.0, 0.0745, 0.0 /                            BLCK332
      DATA CHAEU / .033, .0313, .0393, 9.09 /                           BLCK333
      DATA CHAOC / .0265, .0498, .0438, 7.98 /                          BLCK334
      DATA CHACP / .0545, 3*0.0 /                                       BLCK335
      DATA CHAXX,CHAYY,CHAZZ /  12*0.0 /                                BLCK336
C*********************************************************************
C                                                                    *
C SET UP DEM, SUP, SCRAP AND PAST PROD DATA.                         *
C                                                                    *
C*********************************************************************
      DATA QSUP1 /  0.0, 2065.1, 0.0, 1577.4, 0.0, 504.5, 0.0, 1286.3,  BLCK337
     1 0.0, 167.5, 0.0, 403.6, 0.0, 1742.5, 6*0.0 /                     BLCK338
      DATA QSUP2 / 0.0, 5406.4, 0.0, 406.9, 0.0, 1511.0, 0.0, 336.3,    BLCK339
     1 0.0, 3346.7, 0.0, 414.5, 0.0, 2962.4, 6*0.0 /                    BLCK340
      DATA QSUP3 / 0.0, 140.1, 0.0, 20.1, 0.0, 59.8, 0.0, 54.4, 0.0,    BLCK341
     1 20.8, 0.0, 149.6, 0.0, 188.9, 6*0.0 /                            BLCK342
      DATA QSUP4 / 0.0, 1582.3, 0.0, 973.1, 0.0, 475.3, 0.0, 251.9, 0.0, BLCK343
     1 696.2, 0.0, 473.3, 0.0, 1511.4, 6*0.0 /                          BLCK344
      DATA QSCP1 / 0.0, 495.9, 0.0, 43.9, 0.0, 155.7, 0.0, 0.0, 0.0,    BLCK345
     1 458.8, 0.0, 35.5, 0.0, 0.0, 6*0.0 /                              BLCK346
      DATA QSCP2 / 0.0, 1587.2, 0.0, 91.8, 0.0, 786.5, 0.0, 16.0, 0.0,  BLCK347
     1 1262.9, 0.0, 47.5, 0.0, 0.0, 6*0.0 /                             BLCK348
      DATA QSCP3 /0.0, 12.041, 18*0.0 /                                 BLCK349
      DATA QSCP4 /0.0, 903.8 , 18*0.0 /                                 BLCK350
      DATA QSPRD1 / 0.0, 49684.4, 0.0, 26513.3, 0.0, 8304.4, 0.0,       BLCK351
     1 31661.0, 0.0, 3439.5, 0.0, 4074.0, 0.0, 26265.9, 6*0.0 /         BLCK352
      DATA QSPRD2 / 0.0, 95593.6, 0.0, 24228.4, 0.0, 16747.9, 0.0,      BLCK353
     1 3272.6, 0.0, 43666.6, 0.0, 3604.0, 0.0, 42814.9, 6*0.0 /         BLCK354
      DATA QSPRD3 / 0.0, 6424.0, 0.0, 530.1, 0.0, 267.6, 0.0, 414.2,    BLCK355
     1 0.0, 213.4, 0.0, 2512.6, 0.0, 2929.5, 6*0.0 /                    BLCK356
      DATA QSPRD4 / 0.0, 37584.5, 0.0, 18151.0, 0.0, 7900.6, 0.0,       BLCK357
     1 7396.5, 0.0, 16597.3, 0.0, 11137.5, 0.0, 26099.1, 6*0.0 /        BLCK358
      DATA QDEM1 / 0.0, 2474.0, 2443.2, 2208.1, 0.0, 460.7, 376.1,      BLCK359
     1 390.5, 0.0, 1592.2, 1456.7, 1307.4, 0.0, 94.3, 87.1,             BLCK360
     2 75.8, 0.0, 2721.4, 2636.5, 2649.8, 0.0, 129.1, 125.8, 107.9,     BLCK361
     3 0.0, 2028.7, 1989.9, 1935.6, 12*0.0 /                            BLCK362
      DATA QDEM2 / 0.0, 5357.7, 5316.9, 5088.4, 0.0, 563.3, 479.9,      BLCK363
     1 435.8, 0.0, 2470.8, 2354.7, 2032.1, 0.0, 150.6, 140.1, 126.7,    BLCK364
     2 0.0, 3707.5, 3416.0, 3340.6, 0.0, 223.0, 206.9, 193.5,           BLCK365
     3 0.0, 2928.1, 2879.9, 2767.7, 12*0.0 /                            BLCK366
```

```
      DATA QDEM3 / 0.0, 195.4, 175.9, 149.8, 0.0, 12.2, 11.2, 10.0,      BLCK367
     1 0.0, 143.3, 109.0, 107.0, 0.0, 5.4, 5.2, 5.2, 0.0, 230.4,          BLCK368
     2 206.4, 183.1, 0.0, 5.3, 5.3, 4.3, 0.0, 171.1, 168.8, 165.1,        BLCK369
     3 12*0.0 /                                                            BLCK37C
      DATA QDEM4 / 0.0, 1254.1, 1196.1, 1132.4, 0.0, 333.4, 302.7,       BLCK371
     1 254.8, 0.0, 1222.0, 1148.0, 1063.2, 0.0, 122.4, 115.2, 90.5,       BLCK372
     2 0.0, 1541.5, 1623.0, 1497.1, 0.0, 118.7, 100.5, 95.9, 0.0,         BLCK373
     3 1515.1, 1515.3, 1443.2, 12*0.0 /                                    BLCK374
C*********************************************************************
C                                                                    *
C   SETUP DEFAULT PROGRAM PARAMETERS                                 *
C                                                                    *
C*********************************************************************
      DATA ICNTRY,IYR,IPRICE,IQDEM,IQSUP,IQSCP / 7,80,11,10,13,13 /     BLCK375
      DATA IYRSIM,IYRFST,IWORLD / 10, 81, 8 /                            BLCK376
      END                                                                  BLCK377
```

APPENDIX B
INSTRUCTIONS FOR UPDATING AND MODIFYING THE PROGRAM

As new data becomes available, users will want to update this computer simulation model. Furthermore, it may be that users may find it necessary to change the parameters in the equations themselves. This appendix in conjunction with the comment statements in the program should facilitate such modifications.

Indexing Conventions

The following indexing conventions have been employed in this program:

Minerals

Denoted by IMINRL, the following numeric values are employed

Mineral	IMINRL
Copper	1
Aluminum	2
Nickel	3
Zinc	4
Modified Nickel	5

Country Groups

Country Group	Alphabetic Index	Numeric Index
North America	NA	1
South America	SA	2
Asia	AS	3
Africa	AF	4
Europe	EU	5
Oceania	OC	6
Centrally Planned	CP	7
Additional Country Groups	XX	8
Additional Country Groups	YY	9
Additional Country Groups	ZZ	10

Time

Period	Index
Current year (t)	1
Lagged one year (t-1)	2
Lagged two years (t-2)	3
Lagged three years (t-3)	4

Basic Design

This program operates on large arrays which are generally 2 or 3 dimensional. In BLOCK DATA, these arrays are equivalenced down to one-dimensional arrays. These one-dimensional vectors correspond to country groups and/or minerals and are named as follows

	Copper	Aluminum	Nickel	Zinc
Price Equation Coefficients	PRCF1	PRCF2	PRCF3	PRCF4
Demand Equation Coefficients	DMcc1	DMcc2	DMcc3	DMcc4
Primary Production Equation Coefficients	SPcc1	SPcc1	SPcc3	SPcc4
Secondary Production Equation	SRcc1	SRcc2	SRcc3	SRcc4

where cc indicates the alphabetic index of the country group in question.

Data Input

The necessary data is inputted into the program in the following manner:

Exogenous Variables

The initial values for the exogenous variables — i.e., income, the interest rate, the rate of growth of the capital stock, and the rate of growth of the money supply — are entered in the array EXPARM. This array is of dimension t x i x CG where

t = time = 1, 2

i = 1 for income

2 for the interest rate

3 for the growth rate of the capital stock

4 for the growth rate of the money supply

CG = the country group = 1, 2, . . ., 10

The rates of growth of income, the capital stock, and the money supply, as well as the interest rate are entered in the array DOTVAR. This array has dimension j x CG where

j = 1 for the income growth rate

2 for the interest rate

3 for the growth rate of the capital stock

4 for the growth rate of the money supply

CG = the country group = 1, 2, . . ., 10

Note that all growth rates except capital are stored internally in decimal form — i.e., 10% = 0.10. In the case of capital, the data is stored as a percentage — i.e., 10% = 10.0.

The initial prices for the related commodity are entered as PRICE. This variable will be discussed below. The rates of change in the price of the related commodities are entered as PRDOT. This variable is of dimension IMINRL where

IMINRL = 1 for aluminum price (i.e., copper simulations)
2 for copper price (i.e., aluminum simulations)
3 for steel price (i.e., nickel simulations)
4 for steel price (i.e., zinc simulations)

The array EXPARM is equivalenced to ten vectors with names of the form EXPcc, where cc is the alphabetic index of the country group. These vectors take the form

$$EXP = (Y_{t-1}, Y_t, r_t, r_{t-1}, \dot{K}_t, \dot{K}_{t-1}, \dot{M}_t, \dot{M}_{t-1})$$

For example, the vector EXPNA is the vector of exogenous variables for North America. In a similar manner, the array DOTVAR is equivalenced to ten vectors of the form CHAcc. These vectors appear as

$$CHA = (\dot{Y}, \dot{r}, \dot{K}, \dot{M})$$

Historical Values for the Endogenous Variables

The historical data for price, quantity demanded, primary production, secondary production, and the sum of past production are entered in the following manner.

Mineral prices are entered in the array PRICE. This array is of dimension i x t x IMINRL, where

i = 1 if the price is for the mineral itself
= 2 if the price is for the related mineral
t = time = 1, 2, 3
IMINRL = 1 for copper simulations
2 for aluminum simulations
3 for nickel simulations
4 for zinc simulations

Quantity demanded is entered in the array QDEM. This array is of dimension t x CG x IMINRL, where

t = 1, 2, 3, 4
CG = country group = 1, 2, . . ., 10
IMINRL = 1, 2, 3, 4

Primary production is entered in the array QSUP. This array is of dimension t x CG x IMINRL as above. Likewise, secondary production is entered as the array QSCP of dimension t x CG x IMINRL and the sum of past production is entered as the array QSPROD of dimension t x CG x IMINRL.

The array QDEM is equivalenced to 4 vectors with names of the form QDEMi, where i is the mineral index (IMINRL). Thus,

$$QDEMi = D_{1,1}, \ldots, D_{1,10}; D_{2,1}, \ldots, D_{2,10}; D_{3,1}, \ldots, D_{3,10}; D_{4,1}, \ldots, D_{4,10})$$

For example, QDEM1, is the vector of consumption by country group for copper. In a similar manner, QSUP is equivalenced to 4 vectors with names QSUPi, QSCP is equivalenced to 4 vectors with names QSCPi, and QSPROD is equivalenced to 4 vectors with names QSPRDi.

Program Parameters

In the following, the procedure for inputting the parameters of the individual equations is described. This procedure will be necessary if the user, for any reason, wishes to change a parameter value. However, the user should note that, if the values of the exogenous variables or the historical values of the endogenous variables are changed, it is likely that the constants in some of the equations will have to be altered in order to adjust the model to the new data set.

The coefficients of the price equations are entered in the array PRCOEF. This array is of dimension ICOEF x IMINRL where

ICOEF = the variable number for the desired coefficient = 1, 2, . . ., 15 (See Table B-1)

IMINRL = 1, 2, 3, 4

This array is equivalenced to four vectors — one for each mineral — with names PRCFi, where i = IMINRL.

The coefficients of the demand equations are entered in the array DMCOEF. This array is of dimension ICOEF x CG x IMINRL. (See Table B-1 for the coefficient numbers.) Likewise, the coefficients of the primary production equations are entered in the array SPCOEF with dimension ICOEF x CG x IMINRL and at the secondary production equations are entered in the array SRCOEF with dimension ICOEF x CG x IMINRL. Each of these arrays is equivalenced to 40 vectors — one each for the 10 country groups and 4 mineral commodities — with names of the form DMcci, SPcci, and SRcci where cc is the alphabetic index for the country group and i is the mineral index. For example, DMCP3 denotes the demand function coefficients for the centrally planned economies for nickel.

TABLE B-1
EQUATION PARAMETERS

Coefficient \ Equation	Price	Consumption	Primary Production	Secondary Production
1	Constant	Constant	Constant	Constant
2	$P_{M,t-1}$	$(P_M-P_R)_t$	$P_{M,t}$	$P_{M,t}$
3	$P_{M,t-2}$	$(P_M-P_R)_{t-1}$	$P_{M,t-1}$	$P_{M,t-1}$
4	$(WS+WSP-WD)_{t-1}$	$(P_M-P_R)_{t-2}$	$P_{M,t-1}$	$P_{M,t-2}$
5	$\sum^{j}\sum^{j} S_{ji}$	$(WS-WD)_{t-1}$	$ROWS_{t-1}$	QD_t
6	t	Y_t	W_{Dt}	QD_{t-1}
7	Y_{NA}	Y_{t-1}	WD_{t-1}	QD_{t-2}
8	r_{NA}	$\dot{K}_{t-1}$	WD_{t-3}	QD_{t-3}
9	$P_{R,t}$	$\dot{M}_{t-1}$	t	$QSCP_{t-1}$
10	$P_{R,t-1}$	$QDEM_{t-1}$	r_t	WD_t
11	$P_{R,t-2}$	–	r_{t-1}	WD_{t-1}
12	–	–	$\sum^{t-2} S_i$	WD_{t-2}
13	–	–	QS_{t-1}	WD_{t-3}
14	–	–	–	–
15	–	–	–	–

SIMTEX PURCHASE

The latest version of the SIMTEX program listed in Appendix A is available on magnetic tape for purchase by interested parties for $2,500.

Program tapes have been prepared for use on most IBM and DEC (Digital) installations.

The program, written in FORTRAN IV, is fully documented by imbedded comments.

For more information please contact:

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The purchase price does not include installation, maintenance, training or periodic upgrading of the program. However, purchasers of SIMTEX tapes will be given the option of receiving newer versions of the program from time to time for the additional costs of a tape, file transfer to tape and tape shipment only.

DISCLAIMER: Neither the authors of the SIMTEX program nor the Ministry of Natural Resources nor the government of Ontario guarantees that the SIMTEX program is suitable for any particular purpose. None of the above parties will accept liability for the results of errors or omissions in the program or for misuse of the program or for any consequences, direct or indirect, however arising from the program's use.

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